DECEMBER 1956

75 YEARS OF PROGRESS
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Journal
AMERICAN WATER WORKS ASSOCIATION

In this issue

Journal

AMERICAN WATER WORKS ASSOCIATION

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December 1956

Vol. 48 • No. 12

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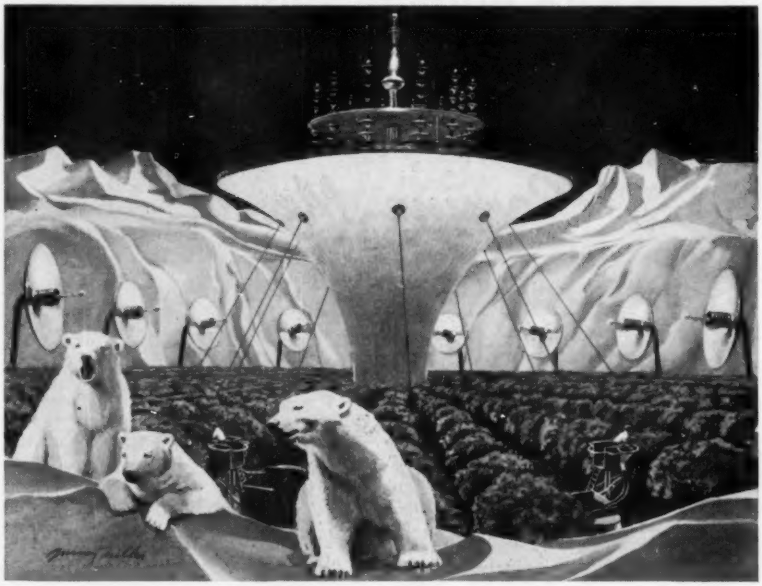

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1957

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Feb. 6–8—Indiana Section, at Sheraton-Lincoln Hotel, Indianapolis. Secretary, Robert J. Becker, Supt. of Purif., Indianapolis Water Co., 113 Monument Circle, Indianapolis 6.

Feb. 14—New Jersey Section Midwinter Luncheon, at Hotel Essex House, Newark. Secretary, A. F. Pleibel, 683 Prospect St., Maplewood.

Mar. 17–20—Southeastern Section, at Francis Marion Hotel, Charleston, S.C. Secretary, N. M. deJarnette, Engr., Div. of Water Pollution Control, State Dept. of Public Health, 245 State Office Bldg., Atlanta 3, Ga.

Mar. 20–22—Illinois Section, at LaSalle Hotel, Chicago. Secretary, Dewey W. Johnson, Research Engr., Cast Iron Pipe Research Assn., 122 S. Michigan Ave., Chicago 3.

Apr. 4–6—Arizona Section, at Maricopa Inn, Mesa. Secretary, H. C. Bigglestone, Luhrs Tower, Phoenix.

Apr. 5–6—Montana Section, at Rainbow Hotel, Great Falls. Secretary, Arthur W. Clarkson, Acting Chief, Water Sec., Div. of Environmental Sanitation, State Board of Health, Helena.

Apr. 10–12—Kansas Section, at Broadview Hotel, Wichita. Secretary, Harry W. Badley, Repr., Neptune Meter Co., 119 W. Cloud St., Salina.

Apr. 10–12—New York Section, at Mark Twain Hotel, Elmira. Secretary, Kimball Blanchard, New York Branch Mgr., Rensselaer Valve Co., c/o Ludlow Valve Co., 11 W. 42nd St., New York.

Apr. 24–26—Nebraska Section, at Cornhusker Hotel, Lincoln. Secretary, John E. Olsson, 408 Sharp Bldg., Lincoln.

(*Continued on page 8*)

Coming Meetings

(Continued from page 6)

May 2–4—Pacific Northwest Section, at Winthrop Hotel, Tacoma, Wash. Secretary, Fred D. Jones, Asst. Supt., Water Dept., Rm. 306, City Hall, Spokane, Wash.

Jun. 12–14—Pennsylvania Section, at Bedford Springs Hotel, Bedford Springs. Secretary, L. S. Morgan, Div. Engr., State Dept. of Health, Greensburg.

Jun. 17–19—Canadian Section, at Royal Alexandra Hotel, Winnipeg, Man. Secretary, A. E. Berry, Director, San. Eng. Div., Ontario Dept. of Health, 72 Grenville St., Toronto, Ont.

Sep. 4–6—Wisconsin Section, at Hotel Schroeder, Milwaukee. Secretary, Harry Breimeister, Chief Utility Engr., City Engineer's Office, City Hall, Milwaukee 2.

Sep. 11–13—New York Section, at Whiteface Inn, Lake Placid. Secretary, Kimball Blanchard, New York Branch Mgr., Rensselaer Valve Co., c/o Ludlow Valve Co., 11 W. 42nd St., New York.

Sep. 18–20—Ohio Section, at Netherland Plaza Hotel, Cincinnati. Secretary, M. E. Druley, Dist. Mgr., Dayton Power & Light Co., Wilmington.

Sep. 23–25—Kentucky-Tennessee Section, at Brown Hotel, Louisville, Ky. Secretary, J. Wiley Finney Jr., Howard K. Bell, Cons. Engrs., 553 S. Limestone St., Lexington, Ky.

Sep. 25–27—Michigan Section, at Leland Hotel, Detroit. Secretary, T. L. Vander Velde, Chief, Sec. of Water Supply, State Dept. of Health, Lansing 4.

Sep. 25–27—North Central Section, at Gardner Hotel, Fargo, N.D. Secretary, L. N. Thompson, 216 Court House Bldg., St. Paul 2, Minn.

Sep. 29–Oct. 1—Missouri Section, at Sheraton-Jefferson Hotel, St. Louis. Secretary, W. A. Kramer, State Office Bldg., Jefferson City.

Oct. 13–16—Southwest Section, at Skirvin Hotel, Oklahoma City, Okla. Secretary, Leslie A. Jackson, Mgr.-Engr., Water Works, Robinson Memorial Auditorium, Little Rock, Ark.

Oct. 16–18—Iowa Section, at Fort Des Moines Hotel, Des Moines. Secretary, J. J. Hail, Supt., Water Dept., City Hall, Dubuque.

Oct. 20–23—Alabama-Mississippi Section, at Buena Vista Hotel, Biloxi, Miss. Secretary, C. M. Mathews, Public Service Com., 119 W. Commercial St., Yazoo City, Miss.

Oct. 24–26—New Jersey Section, at Hotel Madison, Atlantic City. Secretary, A. F. Pleibel, 683 Prospect St., Maplewood.

Oct. 30–Nov. 1—Chesapeake Section, at Sheraton-Park Hotel, Washington, D.C. Secretary, C. J. Lauter, 6955—33rd St., N.W., Washington, D.C.

Oct. 30–Nov. 1—California Section, San Jose. Secretary, Henry J. Ongerth, Sr. San. Engr., Bureau of San. Eng., 2151 Berkeley Way, Berkeley.

Nov. 6–8—Virginia Section, at Hotel Roanoke, Roanoke. Secretary, J. P. Kavanagh, Dist. Mgr., Wallace & Tiernan Inc., 213 Carlton Terrace Bldg., Roanoke.

Nov. 11–13—North Carolina Section, at Hotel Sir Walter, Raleigh. Secretary, W. E. Long Jr., State Stream Sanitation Com., Raleigh.

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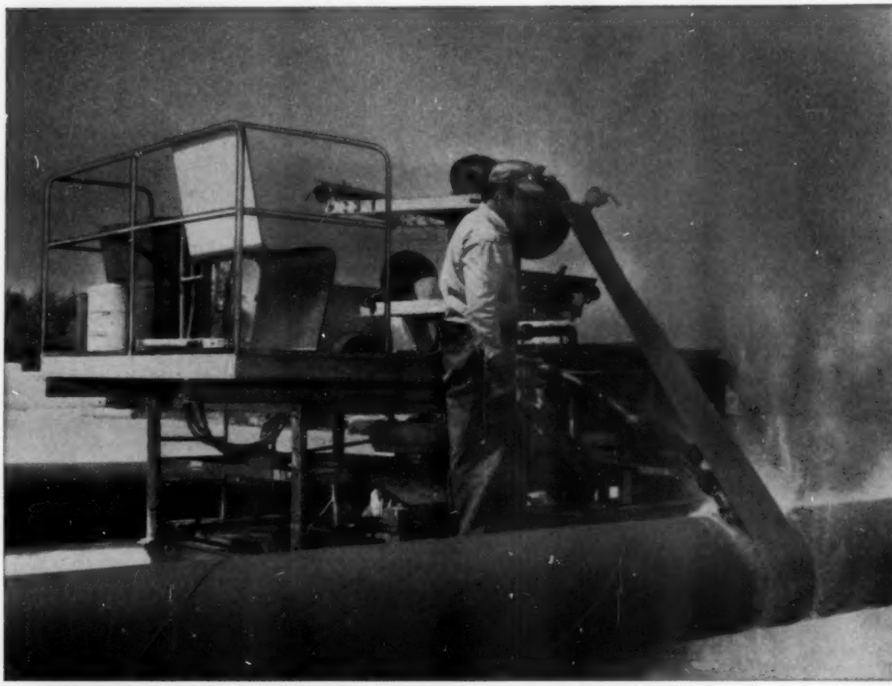

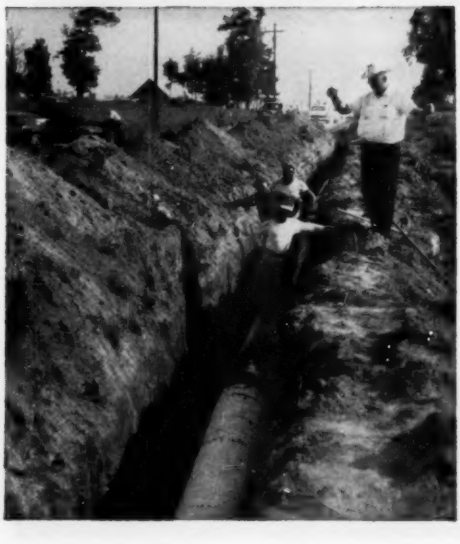

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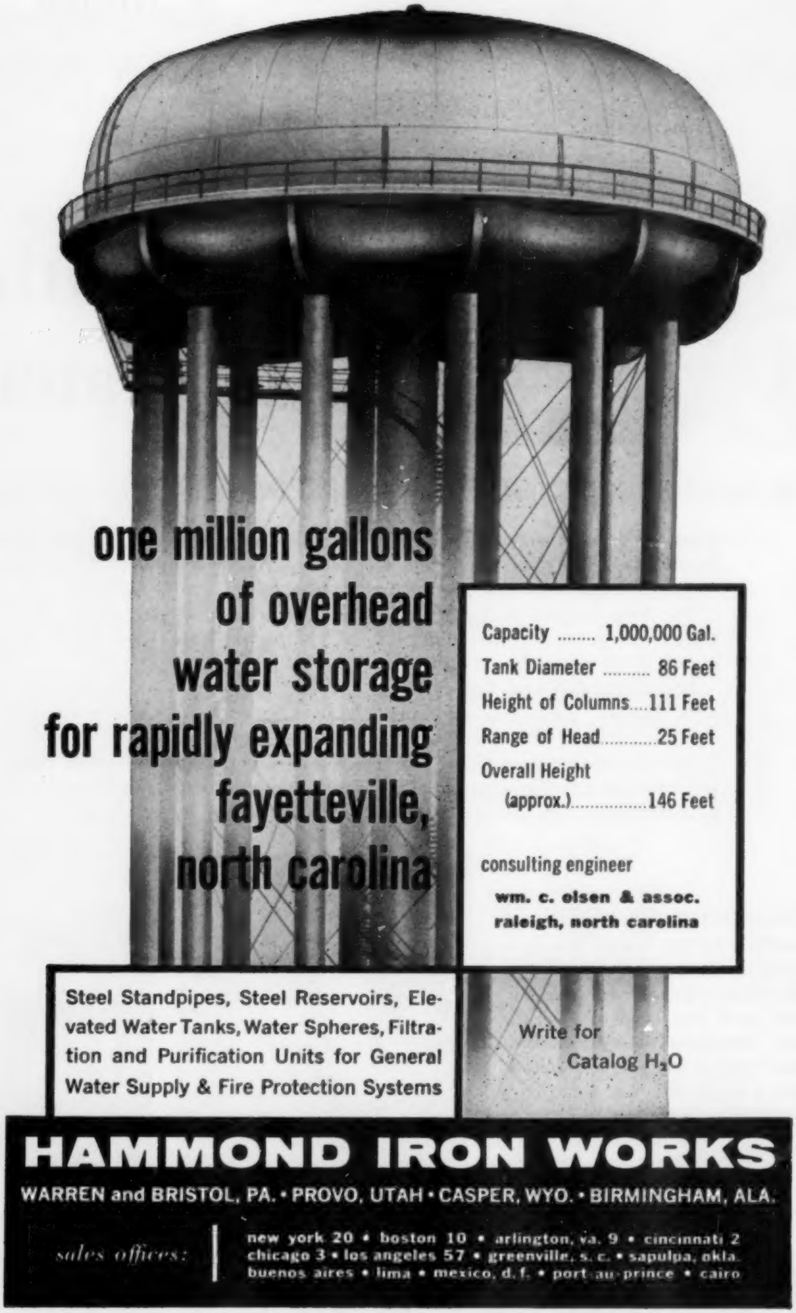
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for rapidly expanding
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Tank Diameter .... 86 Feet
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Long-Range Planning for Water Service

Abel Wolman

A paper presented on Oct. 10, 1956, before the Pennsylvania Water Works Assn., Atlantic City, N.J., by Abel Wolman, Prof. of San. Eng., Johns Hopkins Univ., Baltimore, Md.

THE record in the United States for providing water service, is one of which any citizen may be justly proud. Perhaps in no other country in the world has public water supply been so widely provided, at such low cost, as in this country. Why, then, should one still be concerned with the subject of long-range planning for water services?

The history of water service demonstrates that the problems of planning have long confronted the professional practitioner. Emphasis on such planning is not new, and the literature in the water works field is filled with careful, technical consideration of the complex problems of providing water.

In the last two decades, the nature of such planning, however, has been modified. A long look at the water issues which now concern the professional worker, discloses a somewhat different and broader aspect. One of the major characteristics of water supply service in the past has been, with some important exceptions, that it has been confined largely to the development and extension of water service within limited political boundaries—usually those of the familiar municipality. These problems, within such circumscribed areas, have been resolved over the years with skill and with economy. Where the actual execution of solutions has lagged, the causes have been essentially of a political, administrative, or fiscal nature.

New Problems

Today, however, we are confronted with a new set of issues, which represent the subject of this paper. The changes which create new or intensify old problems are those which we generally ascribe to metropolitan areas. The phenomena associated with the growth of the metropolitan areas are of relatively recent origin. They confront the developer of water service

with issues broader in scope, wider in geographical coverage and of a more amorphous character than any previous issues. The metropolitan areas, likewise, represent a nationwide, rather than a local or regional, development. It is within this particular setting that the long range planning of water service is here discussed.

In 1956, approximately 172 metropolitan areas with well defined characteristics exist in continental United States. Some 42 states and the District of Columbia are represented by such areas. Only the states of Idaho, Montana, Nevada, North Dakota, Vermont and Wyoming do not contain at least some areas within the current Census Bureau definition. More than half of the nation's population now lives in metropolitan areas, thus accounting for something approaching 90,000,000 people.

Not all of these areas, of course, are enormous in size, although there are 33 of these which have populations in excess of 500,000. The areas apparently are growing in acreage and in population, and will undoubtedly, by 1960, account for over 100,000,000 people.

The significance of these figures lies in the fact that the country was generally unprepared to meet the utility requirements of population which spilled beyond the political units normally geared to meet such needs. The unfortunate results of this lack of preparedness, not only in technology, but in administrative structure and finance, are a familiar story.

Efforts to meet these growing problems have ranged from the successful devices used for years in the Boston Metropolitan District and in the Washington Suburban Sanitary District, to completely chaotic and hand-to-mouth operations in most other metropolitan areas. In these latter cases, the situation has successfully escaped the impact of careful, advanced thinking. As a result, the next quarter of a century will obviously show the necessity for major reconstruction, considerable duplication in expenditures, or increasingly limited water service.

Both private and public workers in this field have defaulted in not visualizing realistically the nature of the problem, or have been slow in implementing new solutions. Orthodox water planning, geared to restricted geographical areas, and to the considerations of earlier decades, has inhibited more imaginative solutions. The traditional political boundary has, perhaps, played an unfortunate part in restraining water service—whether the service was publicly or privately owned. An awareness of these realities is a prerequisite to solving problems which new and unexpected demands have posed.

It is not the purpose of this paper to present a check list of the items to be kept in mind in planning for water service. Such check lists have been authoritatively presented in the professional journals, and little needs to be added to them, since they afford excellent and detailed guide lines for the interested worker.

The most useful approach would be to discuss those guiding principles which must be rigorously re-examined, if we are to recover and guarantee continuation of adequate water service in the metropolitan areas. These principles may be assumed to cover some five major areas: technology, administrative structure and management, finance, research, and legislation.

Technology

Although it may be stated with some assurance that the technological prospect of providing water service in metropolitan areas is most encouraging, one should not lose sight of the fact that, even in this aspect, much remains to be done to expand the quality of water service. Perhaps one of the most critical features in this field is the increasing tendency to neglect the complex problems of distribution. The present emphasis in distribution diagnosis and design has its roots in the traditional adherence to more densely populated areas already referred to. If people had not elected, in the last two decades, to move in increasing numbers to less densely settled areas and to properties with more lawn space, the orthodox water distribution design would still serve without serious defects.

These suburban shifts in demand are the subject of a wide variety of diagnostic studies in many parts of the United States. They represent a growing recognition of the fact that the changing demands for water force a prompt and new evaluation of the best way to distribute it. The situation obviously will not be met by privately lamenting the extraordinary habits of the American people and by resisting to the last ditch their insistence on using water for purposes which they prefer.

The prime necessity in technology is an immediate evaluation of the new requirements. At the same time the translation of these requirements into actual availability has always taken too long. The author recently reviewed the steps required to complete the construction of the Savage River Dam in the state of Maryland. The dam was designed to increase the low flow of the Potomac River for water and stream pollution abatement. The proposal for this project was initiated before 1931. Its development wandered through decades of fits and starts, several wars, a depression, minor financial emergencies, international diplomatic battles, controls on materials and labor, and repeated, though successful, efforts for the raising of additional moneys. In 1951, more than 20 years after the initiation of the idea, the dam was finished and ready for operation, with water actually being released to afford the benefits originally contemplated.

The experience of New York City in the development of its additional water sources over the last quarter of a century is a further demonstration of the long time lag which has plagued the water works industry throughout its history.

These delays, of course, were not due to technological deficiencies, but to man-made obstacles, aided and abetted by the snail-like processes which have controlled most public practice throughout our history. It is unfortunate that many people now adopt the fatalistic attitude that nothing can be done to speed up the processes of water utility development in this country. The time lag cannot be accepted for the forthcoming decades, since the problems are now at our door, calling for immediate rather than deferred decisions and action. In this respect, the technological solutions should be used as the tools for speed rather than the issues as the bases for delay.

Administration

Far too little consideration is given to the development of administrative devices designed to provide answers to

water works problems. For the most part, rural county administration is still used in an attempt to solve essentially urban utility problems. The core municipality is still viewed as the primary agent to limit water service in surrounding areas. It is still tacitly insisted that satellite areas design and install water utilities on the most niggardly basis in order to keep within the philosophical scope of the revenue bond. Almost without exception these practices result in inadequacies of system and of service, in the piling up of problems for the future and in intensifying the general feud between the subdivider, the house owner, the county government and the water purveyor. Opportunities for the consolidation of service are great. Obstacles to such accomplishments are equally great. They stand, however, as challenges rather than as reasons for no action.

There are, of course, excellent examples of intelligent, long-range approaches to satisfactory administrative practice. Some of these antedate by years the nature of the problems here described. One should remember that some of the sanitary districts and authorities, operating successfully for decades, were created in the period from 1915 to 1925. They are monuments to the imagination, vision and the long-range planning instincts of distinguished engineers, administrators and statesmen. In view of their existence, as well as of their success, it is disconcerting that the lessons to be learned from them have not been more widely applied.

The most perfect diagnosis and design of a water utility in an expanding area are fruitless without comparable diligence in translating such a system into actuality by creation of agencies to accomplish such purposes.

Finance

One of the major blocks to the provision of adequate service in most metropolitan areas is in the field of finance. Here again, the principles guiding us in the past, with some exceptions, are not adapted to the requirements of the present and the future. In order to circumvent the problems of tax limitations, the last few decades have been characterized by the ascendency of the revenue bond as the savior of the water works industry. That it alone cannot save the industry should be apparent to any careful investigator of the metropolitan problem.

The use of the revenue bond rests upon the assumption that the user of water is naturally the sole source of payment for the system. This fundamental principle is more apparently valid than it is actually so. It was probably close to the truth when the new consumer represented a small slowly accumulating addition to the total body of consumers, when the system was compact in nature and in coverage, when the area was either static or slow in expansion, and when the design could keep reasonable pace with the growing requirements of a compact community. Most of these characteristics are inapplicable to the metropolitan areas as we know them.

Few are willing to acknowledge that the general ad valorem tax and the front foot assessment are essential ingredients of any rapidly expanding water economy. The pursuit of the revenue bond principle to its bitter end in many metropolitan areas has resulted in undersized systems, inadequate operation, almost complete absence of long-range plans, and in the ultimate scrapping of a good many

small systems which were independently financed. All of these untoward results stem from the fact that the present and future participants are unwilling to accept the axiom that a water distribution system is an integrated entity, and not a series of independent units designed and constructed without regard to the ultimate form and balance of an integrated system.

What prevails now in satellite communities are systems of minimum size mains, with each community clinging religiously to a revenue bond principle, wholly inadequate to finance the present or prospective requirements of the area. The eye is focused on the immediate, although the solution must provide for the next 40 or 50 years.

It is interesting to speculate on how long it will be before we all confess that the water utility of the future, within the areas here discussed, must rest upon the combined base of more than one of the following sources of money: The ad valorem tax for the large-size mains required for adequate future service; the front foot assessment for the individual house; and the water consumption payment by the actual user.

To place all the emphasis upon the third of these sources of revenue in the kind of setting which now confronts some 100,000,000 people, is unrealistic, if not already fatal. In addition, such a choice either results in a poor system, or loads the present consumer with the burdens of the future.

Research

One cannot speak of long-range planning for water service without a major emphasis upon the things which we do not know. The range of opportunities for research and development is great. It moves over the entire spectrum from automation to detailed analysis of the impact of the behavior of people upon water use.

The assumption has existed too long that our design should rest upon the fact that, historically, the ratio of the maximum-day consumption to the average day should be 150 per cent. Man has a habit of deviating from the professional's rule.

The professional may elect to ignore man's demands or he may adjust his diagnoses and his solutions to the inevitable. The author has pointed out elsewhere that the lot of the planner would be simpler if there were no people in the world. The fantasy of planning for a water works expansion, independent of and unrelated to the desires and habits of the public, may be entertaining, but is certainly a fruitless effort.

Research will point the way to how the long-range determination of water works needs may be used as a guide for the design and redesign of systems and for their adequate financing and management.

If any of the guiding principles so briefly noted above are to find full implementation, major adjustments in legislation will be required in most parts of the United States. It is not asking too much that the water works practitioner should devote an increasing amount of time to the determination of the kind of legislation so required. He must, in addition, actually prepare or participate in the preparation of such legislation. He must undertake to press for its passage; he must roam the halls of legislative assemblies to advise, to persuade, and to coerce the development of such legislative sanctions.

It is not enough to bemoan the absence of such legislation or to point

out that the engineer is not the logical or appropriate agent for the stimulation of such enactments. Unless the engineer engages in such activities, the probability of crystallizing better practices and of meeting promptly the water demands of the future is exceedingly low.

Conclusion

Adequate water service, at a reasonable price, is an attainable objective. If it has not yet been attained, it is only because the skilled workers in this field have not seen fit to define the objective, to delineate the principles which should control its implementation, to devise the structure for administration and management, and to establish the fiscal principles which might safely and wisely provide the sinews for the project. All of these opportunities are at hand. Many of them have already been partly crystallized. What is lacking is the enunciation of the guiding principles in detail, their acceptance in fact, and their translation militantly into reality. Such a prospect is an exciting one. If this paper has done nothing more than to press forward such an undertaking, it will have accomplished its major purpose.

Cumulative Journal Index for 1940–55 Available

A cumulative index to the JOURNAL for the 16 years from 1940 through 1955 has just been published. The clothbound, 192-page book lists article titles and authors by topic. In addition, it contains an alphabetical index of authors and a geographic index, as well as other features designed to make it an outstandingly useful reference tool. The price for general sales is $4.50; to members paying in advance, $3.60. Orders should be sent to: Order Dept., American Water Works Assn., 2 Park Ave., New York 16, N.Y.

Meeting Industrial Water Requirements

John R. Bettis

A paper presented on Mar. 21, 1956, at the Southeastern Section Meeting, Augusta, Ga., by John R. Bettis, Mgr. & Engr., Comrs. of Public Works, Charleston, S.C.

A WATER supplier should be well prepared with both plans and financing in order to meet any expansion necessary to serve an industry. By having these plans ready, the necessary construction within the water works can usually be completed by the time the industry is ready for the water. It is not necessary to have cash in the bank, ready to meet the expansion, although the information necessary for floating a bond issue should be kept up-to-date, and the various bond houses should be kept informed about the financial condition of the water utility. This facilitates sale of the bonds and prevents delay in establishing credit.

In the last few years, drought conditions over the entire United States have forced industry to examine thoroughly the water supply in a community before locating there. Preliminary surveys include requests of the water superintendent to determine the quantity available, price, and chemical suitability of the water.

Those who take water from a stream may have felt in the past that the stream could supply an unlimited quantity of water. During the summers of 1954 and 1955, however, conditions were probably found to be otherwise. Those who take water from wells may have felt that there was an abundance in the ground, obtainable simply by sinking additional wells. This viewpoint also proved to be wrong, in most localities, during the summers of 1954 and 1955.

In order to determine whether water is available for a new industry, it is necessary to decide what the capacity of the plant is at the present time, what the demand load is for domestic and other industrial customers, and what the demand load probably will be after the industry has located in the area and brought in additional workers. If, after these allotments, a surplus remains, then negotiations with the new industry can begin. If the water needed is finished water, of the same quality as that sold to domestic and other industrial customers, it should be sold to the industry at regular, established rates.

In addition to the regular rates, it may be and frequently is necessary, to lay a fixed, monthly charge on the new industry to pay for additions such as pipelines, pumps, and so on, that will have to be installed to furnish the additional water. It would be wise for any community, before it entered into a fixed-charge contract of this type, to check state laws concerning the allowable duration of such a contract. South Carolina law, for example, limits most communities to a contract period of only 2 years.

Typical Contract

A contract recently entered into by Savannah, Ga., is typical. It provides that the company will take a minimum

of 900 mil gal of water per year and will pay for the water at the rate charged other customers. In addition, a minimum of $25,081 per year is to be paid as long as any bonds issued for improvements (needed to supply this water) are outstanding. The city has agreed that this payment would be placed in a special fund to redeem the bonds. This kind of arrangement is usually of benefit to both the community and the industry.

In Charleston, two cases displaying some unusual aspects are those of the West Virginia Pulp & Paper Co. and the United Piece Dye plant. The former required a minimum of 25 mgd, but existing facilities were able to supply only 5 mgd. Many years before, Charleston had considered using the Edisto River as a supplementary supply. Using those earlier plans now, the community was able to more than meet the requirements of the new industry. State legislation was necessary to allow the water commission to enter into a 50-year contract with the paper company. The water used is raw, as it comes from the Edisto River, and is not processed in any way by the water works. It was necessary for the city to issue $1,000,000 in bonds to finance the expansion of this water supply, and the charges to the company paid approximately the interest on these bonds. This arrangement was of mutual benefit to the company and the community, providing good water at reasonable prices to the former, and putting the latter in a position to meet the water demand during and after World War II. Negotiations are now underway for an increase in the quantity now consumed, with the company sharing the cost of any necessary expansion of the water facilities.

The dye plant contract provided for installation of the company's pumps in the sedimentation basin, at the point where the water leaves the basin on its way to the filter plant. Payment for this water was made as a flat monthly fee, based on the cost of the new facilities needed to furnish this water, plus an additional sum for the water and pumping cost. The contract with the dye company provides an option on obtaining raw, settled, or finished water. Finished water is paid for at the same rates as any other customer, and the monthly fee, to cover the investment, is paid regardless of the type of water used.

Some cities have entered into special contracts with industrial customers, under which an industry pays a slightly lower rate on condition that it takes its water during off-peak periods and stores it in reservoirs or tanks for use whenever the drain on the city system is greatest. Other towns whose distribution mains and trunk mains are not large enough to supply industry during periods of normal or peak consumption, will enter into a contract with an industry to supply water, if it is taken during off-peak periods. Both arrangements usually benefit the industry and the supplier.

Conclusion

When meeting new industrial needs, the chief considerations of the public water supplier should be: [1] Does it harm the domestic or industrial customers already being supplied by the system? [2] Will meeting industrial requirements prove a financial burden on the community? If the answer to both these questions is "no," then the community should do all in its power to supply the industries with the best quality water available.

Indexes of Water Works Construction Costs

Ernest C. North

A paper presented on Oct. 25, 1956, at the Chesapeake Section Meeting, Baltimore, Md., by Ernest C. North, Assoc. Engr., Whitman, Requardt & Assocs., Baltimore, Md.

MANAGEMENT of private electric and gas companies has been aware of the value of index numbers for many years, and many such companies have used them continuously since the early 1920's. When regulatory bodies began to insist that original cost records should be kept accurately, many utilities which did not keep accurate records of original costs used index numbers to trend repriced inventories of properties back to estimated original costs at the time of installation. As soon as original costs records were established, many utilities again used index numbers in rate cases. These were used to trend the original costs to estimated reconstruction costs new, as of the date they filed for rate adjustments. They are widely used for this purpose today, because many states recognize reconstruction costs new as one of the measures of fair value. Index numbers are also used to trend original costs to reconstruction costs new to establish reasonable insurance coverage.

Definition

An index number is a percentage relation between the cost of an article, or the whole or portion of a plant at any stated time, and the cost of that same article, or the whole or portion of a plant at any fixed or base period. Stated as a formula, index number is

$$\frac{\text{Cost at a stated time}}{\text{Cost at base period}} \times 100.$$

If 10-in. Class 150 cast-iron pipe costs \$3.25 per foot on Jan. 1, 1956, and during a 1938 base period the same pipe cost \$1.47 per foot, the index number for Jan. 1, 1956 would be $\frac{3.25}{1.47} \times 100$ or 221. In other words, the pipe in 1956 costs 2.21 times its cost in 1938. The ratio between index numbers of any two periods gives a multiplier by which to translate a known cost at one period to the cost at the other period.

For the past 30 years, Whitman, Requardt and Associates have published index numbers for the trending of public utility construction costs.* This index, on an annual subscription basis, has demonstrated the value of their method of translating original costs to values expressed in terms of present-day dollars. Index numbers are made especially for the electric and gas industries. Index numbers can also be used in reverse to translate today's costs back to estimated original costs.

Previous Index Series

There are published index series which cover a vast number of subjects. Perhaps the best known in the water works industry are the two published by *Engineering News-Record*, one on building costs and the other on

* Handy Index, later known as Handy-Whitman Index, is published by Whitman, Requardt & Assocs., Baltimore, Md.

construction costs. In spite of the fact that the *Engineering News-Record* index series are of a general nature, they have been remarkably accurate as to direction of trend, and reasonably accurate as to magnitude of trend. Another index series frequently mentioned is the Bureau of Labor Statistics Consumer Price Index; many labor contracts are hinged to this index, thus providing a measure of protection to wages against attrition caused by increase in the cost of living rates. Many other indexes are published: The Interstate Commerce Commission issues a Railroad Cost Index, and the Bureau of Public Roads has one on highway costs.

Until about 1953, the water works industry had only the general index series on which to rely for indications of cost trends. Henry H. Fick (*1*) made known an index series which he had built by consolidating many published index series such as the *Engineering News-Record* Building Cost Index and Construction Cost Index, Marshall and Stevens Index, E. H. Boeckh and Associates Index, Brick and Concrete Commercial Building Index, *Iron Age* Indexes, Interstate Commerce Commission Railroad Construction Index, Handy-Whitman Index and other information from private sources. It was an excellent piece of work, and, for the first time, gave the water works industry index numbers made especially for water properties. As a result of Fick's article, Whitman, Requardt and Associates received a great number of requests to establish a series of index numbers pertinent only to water works properties. These requests did not reflect doubt on the general accuracy of Fick's series, but rather, seemed inspired by a desire to have a series built from the ground up, thus carrying greater weight before regulatory bodies and courts in states that accept reconstruction costs new as one of the measures of fair value. This series would also be of use to the water works industry for estimating adequate insurance coverage, back trending to determine original costs, and so on.

Need for Series

The reasoning behind this has its roots in a US Supreme Court opinion, Jun. 3, 1935, in the case of *West et al.* v. *C & P Telephone Company,* Baltimore, Md. *"West et al."* means the Maryland Public Service Commission. In this case, the Maryland commission has used sixteen commodity indexes, weighted together on some principle which they did not disclose, to trend the cost of telephone property. The court declared: "This method is inappropriate for obtaining the value of a going telephone plant. An obvious objection is that the indexes which were its basis were not prepared as an aid to the appraisal of property. They were intended merely to indicate price trends." The court further stated that "this is not to suggest that price trends are to be disregarded; quite the contrary is true." In other words, the court apparently said that it is better to use index numbers specifically designed and constructed for the type of properties being appraised.

Early in 1954 Whitman and Requardt began work on a series of index numbers applicable to water works properties. This series is of more than routine academic interest in spite of the fact that a water works system may be owned and operated by the public and therefore exempt from regulation by any state regulatory body. There was, however, no public ownership in Maryland.

Hagerstown, Md., has been supplying water to its inhabitants and those of the surrounding territory since 1918. During these years, the following five points guided operations:

1. Is there a sufficient quantity of water?
2. Is it good, potable water?
3. Is the water plant adequate?
4. How much does the water department cost the city in a year?
5. How much revenue does the city receive from the sale of water?

The city fathers gave little thought to any regulatory phases of the water business. In November 1955, the county commissioners of Washington County petitioned the Maryland Public Service Commission to fix or alter the rates for water supplied to county customers by the city of Hagerstown, in conformance with Chapter 441, Sec. 48 of the Acts of 1955 of the General Assembly of Maryland. So for the first time in the history of the state, a municipally owned utility found itself involved in rate proceedings before the Public Service Commission.

On the first day of the hearing before the commission, the city auditor testified that the property records of the water department had been kept haphazardly. In fact, prior to 1945, there was no continuing property record. Depreciation costs had been calculated according to a formula which had little reference to the actual state of equipment. In short, the records of the department had not been kept in accordance with the Uniform System of Accounts prescribed by the Maryland Public Service Commission. But the city now had a rate case, and one of the measures of value used in establishing a base rate is the original cost of the property used and still useful in public service. Calculating original cost presented a very real and difficult engineering problem.

Development of Index

The Whitman and Requardt firm was engaged to make a report to the Hagerstown board of water commissioners on the value of city properties as of Jan. 1, 1956. It was apparent that index numbers would have to be used to trend estimated reconstruction costs new back to original costs at time of installation. The task of dedetermining a correct inventory of properties was quite difficult in itself; reasonably accurate maps of the distribution system were compiled from many sources including the National Board of Fire Underwriters reports, the memories of old employees, and several maps of more recent main extensions. A simpler task was the repricing of the inventory at cost levels prevailing during 1955, and calling this repriced inventory the reconstruction cost new as of Jan. 1, 1956. Dates of installing the various parts of the property, however, were not easily available. Fragmentary records revealed construction dates of items such as treatment plants, pumping stations, and reservoir, and in some cases, gave original costs. On the basis of the information gathered, estimated original cost of the distribution system seemed to represent approximately 65 per cent of the total properties. Exact ages of distribution properties components were unknown.

Population studies and the total revenue shown by annual reports made it possible to discover property acquisition or reconstruction dates. During the years 1946–1955, date of acquisition was placed to the exact year; from 1926 to 1945, age was placed in

5-year units, and prior to 1926, decades were used as standard unit. Once aging and the unit prices of the reconstruction cost were established, there remained only the mathematical task of trending. Using 8-in. cast-iron pipe installed between 1941 and 1945 as an example, the trending process is worked out as follows:

For period 1941–1945, 12,175 units of 8-in. cast-iron pipe at $7.90 per unit were indicated to be on the inventory at an unknown value. As of Jan. 1, 1956, the estimated value was $7.90 per unit, or a total reconstruction new of $96,182. The index number for the period 1941–1945 is 302.8; the Jan. 1, 1956 number is 689.8. The ratio between the two indexes gives the mulplier—0.4389. The multiplier applied to reconstruction cost new gives original cost, which in this example is $42,214. By going through this process for mains, meters, services and hydrants, the original cost of the distribution system was discovered in less than 3 one-man working days.

Although engineers on the staff of the public service commission accepted the inventory and the estimated age of the components, they decided to estimate original costs by going through the laborious task of developing individual type and size unit prices for every year or period in which parts were installed. The commission's engineers were only interested in the original cost of the properties devoted to county use. By their method, they arrived at a figure of $1,557,022. The trending method gave the sum of $1,603,196—only 3 per cent higher than the commissioner's figure. Obviously, both are correct as no one can estimate the cost of a water system this size within a tolerance less than 5 per cent.

This was the first test of the accuracy of these water works indexes in actual practice, although many academic tests had been made.

Index for Publication

The Handy-Whitman Index of Water Works Property Construction Costs, as now proposed for publication, contains index series for 29 water water property items. Fourteen of the items have been selected because they are important accounts in which there is a large investment. They are identified by account numbers taken from the Uniform System of Accounts for Water Utilities prepared by Committee on Accounts and Statistics of the National Association of Railroad and Utility Commissioners (*2*). The remaining fifteen items are miscellaneous in nature, covering either material or labor component. Each of the 29 index series is computed for six geographical divisions of the US as follows:

1. *North Atlantic Division*—Maryland, Delaware, Pennsylvania, New Jersey, New York, Connecticut, Massachusetts, Vermont, New Hampshire, West Virginia, and Maine
2. *South Atlantic Division*—Virginia, Kentucky, Tennessee, North Carolina, South Carolina, Mississippi, Alabama, Georgia, and Florida
3. *North Central Division*—Ohio, Michigan, Indiana, Illinois, Wisconsin, Minnesota, Iowa, Missouri, Kansas, Nebraska, South Dakota, and North Dakota
4. *South Central Division*—Texas, Oklahoma, Arkansas, and Louisiana
5. *Plateau Division*—New Mexico, Arizona, Nevada, Utah, Colorado, Idaho, Wyoming, and Montana
6. *Pacific Coast Division*—California, Oregon, and Washington.

TABLE 1

Cost Indexes, North Atlantic Division*

Item	Account Number	Date 1954 Jan. 1	1954 Jul. 1	1955 Jan. 1	1955 Jul. 1	1956 Jan. 1
Source of Supply Plant						
Collecting and impounding reservoirs	312	253	258	260	265	286
Pumping Plant						
Structures and improvements	321	247	253	258	263	284
Electric pumping equipment	325	219	219	219	214	235
Water Treatment Plant						
Large treatment plant	331–332	239	244	246	250	264
Small treatment plant	331–332	239	243	244	247	262
Transmission and Distribution Plant						
Steel reservoirs	342	271	276	252	274	284
Elevated steel tanks	342	295	297	297	312	322
Distribution mains—average all types	343	254	262	263	267	284
Cast-iron distribution mains	343	263	269	271	275	291
Cement–asbestos distribution mains	343	222	226	227	229	240
Steel distribution mains	343	261	274	274	278	301
Services	345	270	282	283	287	310
Meters	346	258	258	258	275	275
Hydrants	348	254	254	254	229	245
Miscellaneous Items						
Flocculating equipment—installed		224	226	226	227	243
Clarifier mechanisms—Installed		215	217	209	210	225
Filter gallery piping		239	245	248	249	262
Chemical feeders—small		232	232	232	229	252
Chemical feeders—large		341	341	341	406	432
Gate valves		251	251	226	226	235
Pumps		239	239	239	239	263
Meter yokes		179	184	184	203	220
Corporation stops		218	218	233	256	281
Curb stops		216	216	231	254	279
Ready mixed concrete		167	168	174	179	182
Reinforced concrete		228	231	238	244	256
Construction labor—average all classes		251	260	262	265	279
Plumbers		232	242	245	246	262
Common labor		296	308	308	315	337

* 1936 equals 100.

Local conditions of labor and material costs have made these divisions necessary.

The index numbers are computed on an annual basis for 1912–1935, and on a semiannual basis as of Jan. 1 and Jul. 1 from 1936 to date. Each volume will show all index numbers for each item from 1912 to date. A sample index is shown in Table 1.

Intentions have been to provide an index for the water works industry which is complete in its coverage and accurate as to direction and magnitude of trend for all the major items of property. Any constructive criticism will be welcome.

References

1. Fick, Henry H. Cost Indexes for Water Works Property. *Jour. AWWA*, **45**:779 (Aug. 1953).
2. *Uniform System of Accounts for Water Utilities.* National Assn. of Railroad & Utilities Commissioners (1939).

Correction

The paper "Use of Activated Silica at Quincy, Ill.," by Orville J. Smith (September 1956 Journal, Vol. 48, pp. 1169–1173) contained an error. On p. 1170, col. 2, "41°F" in lines 5 and 33 should read "41°Be" (Baume).

Proper Tools for Distribution System Maintenance

Howard W. Niemeyer

A paper presented on Sep. 26, 1955, at the Missouri Section Meeting, Joplin, Mo., by Howard W. Niemeyer, Supt. of Distribution, Indianapolis Water Co., Indianapolis, Ind.

THE saying, "A carpenter is no better than his tools," serves as an appropriate preface to this paper, as it implies both the need for proper tools to do a job, and the need to keep such tools in their best condition for the production of quality work. The saying is not simply an expression of a theory, but is a statement of fact that applies to any kind of work. It is also a fact that tools will not only do a job better than human hands, but will do the job faster. These basic advantages of tools have provided the impetus for our great industrial development.

In modern terminology, a tool is usually defined as any device or method which will increase efficiency of production. Hence, machines and techniques are classed as tools. The definition of a tool, once limited to small, hand operated devices, has now grown to include such things as job evaluations, safety programs, suggestion plans, time studies, training programs and many others. It is in this broad sense that tools can be said to be the keystone of our modern economy, a system which has provided the highest standard of living people have ever enjoyed.

The impact of tools on our ability to produce more and better things in less time, has had many ramifications. As man's productivity has increased (it has been doubled in the last 25 years), so has his worth. Since 1930, wages and salaries have increased 300 per cent. Much of this increase has resulted from upgraded jobs requiring new skills for the operation of tools. Specially trained men are required for machine design, construction, operation, and maintenance. As a result, laborers have been replaced by engineers, machinists, operators, mechanics, and many other skilled specialists. In fact, it is becoming increasingly difficult to find workers for the dirty back-breaking jobs that must still be done. The work week has been shortened without any reduction in weekly earnings. The 60-hr week which was once normal has been replaced by the standard 40-hr, and a 35-hr week is predicted by or before 1970. Two and three weeks vacations are now among the regular conditions of employment, which, along with many other fringe benefits that have been granted during recent years, have further increased the wage costs of doing business.

It becomes ironic that tools used to reduce labor cost, in the end, have increased labor values so that industry is forced to use more tools in order to stay in the competition.

A typical illustration of the progressive effects which tools have on productivity, product quality, and wages in a highly competitive business, is provided by the rubber industry. In 1904, a small automobile tire cost

$35 when manufactured by labor paid an average wage of 40 cents per hour. The service life of that tire was but 2,000 miles. In 1953, a similar-size tire cost only $20.50, although the average wage rate in tire manufacture was $2.35 per hour. The 1953 tire had a service life of 30,000 miles. The yield for one man-hour of work in 1904 was 23 miles and by 1953 it had risen to 3,300 miles. This example provides a measure of the pace competitive industry has set in the development of tools.

Tools in Water Works

Water utilities are in a special position in that they produce a service that is sold without competition, and have thus not been under pressure to improve their marketing position. Utilities, consequently, have lacked a major incentive to develop the use of tools for their operations. Labor costs, however, have now reached such a high level in the spiraling market that labor-saving devices and practices will require more consideration than ever before. Wages have become so high that a high-priced piece of labor-saving equipment can be a bargain. Lastly, water works jobs need upgrading through the use of tools in order to attract the quality of workers needed in the business.

Fig. 1. Interior of Valve-Testing Truck

The mobile phone places operating personnel in direct contact with the pumping station while operating primary valving. The revolution counter for the valve operator can be seen at the bottom of the steering column.

The value of tools to water utilities is not confined to economic advantages alone. Customer relationship is also subject to the same benefits that may be derived from improved operating efficiencies. Today's high standard of living has created greater demands for uniformity and continuity of service. There are no longer "convenient" times to interrupt service, and all essential interruption must be shortened by the use of time-saving tools. When work is being done in congested streets, any reduction in job time will minimize inconvenience to the public and ease public relations.

Improved employee morale is another by-product of the use of tools. Tools generally result in better working conditions, reduce physical efforts needed on a job, and create more job interest. They become evidence to the worker that management has an interest in him and his job. Most surveys of employee opinions place "desire to be recognized" high in the list of things wanted in a job. Employees want to feel that they are an important part of the company's operation. Tools will help recognize that desire.

With this background to the topic under discussion, attention will be

called to some of the many tools available for use in distribution systems. Unfortunately, the operation of a distribution system does not lend itself to automation as do other phases of water works operation such as treatment and pumping. There is no pushbutton method of restoring a broken water main or replacing a customer's water meter. Distribution system work is largely a manual job. Fortunately, however, there are a great many mechanical aids and practices that can be used to reduce labor requirements and improve operating efficiency. A discussion of these many tools has almost unlimited scope so the following enumeration will, by necessity, be brief and incomplete.

Fig. 2. Rear View of Special Maintenance Truck

The air compressor, driven by means of the power takeoff from the truck engine, and the arrangement of the custom body, the hydraulic hoist and the stop light mounting can be seen.

Maps and Records

The basic tools for the operation of any distribution system are complete and accurate maps and records. Failure to keep location records of a system is much like hiding a treasure without mapping its location. Keeping records of physical data as well as location measurements of all mains, valves, hydrants, and service lines, permits efficient planning of work, adequate and correct stocking of repair parts; avoids unnecessary street cuts; and saves job time. Records of valve locations are of particular importance for emergency use because valve boxes are sometimes torn or buried by street maintenance work crews. Primary maps of the system should be available at a moment's notice to all system maintenance crews and office control personnel.

Annual testing programs for valves and hydrants are essential in maintaining efficient operations. A permanent test card system is time saving. Each

valve and hydrant has a separate test card filed under a route number. Selection of testing route is made by considering the most efficient way of traveling. One-way streets, valve and hydrant locations, and divisions of areas by parks, rivers, or railroads must also be considered. Testing crews work

Fig. 3. Valve Operator and Special Hoist

The view shows both the valve operator and the special hoist for lifting manhole covers in use. The flasher lights mounted on truck cab are for traffic warning.

with more speed when using cards rather than maps. The test report is made on the card, also saving much transferring of paperwork.

Recording can be expedited by a new conveyor filing cabinet that places 60,000–120,000 cards (depending on card size) at the finger tips of the clerk. Compared to the old push and pull drawer cabinets, this system saves considerable clerical time in keeping meter history records.

Communications

A second basic tool is an adequate communication system for key employees. Phone systems used for both inner-office and trunk-line services are finding widespread use. Extensions of such systems between desks having daily contacts are well worth their low monthly service charge. Unlisted phones, placed in dispatching and control centers, provide maintenance and service men with ready connections from the field regardless of the load on public phones. These unlisted phones are of invaluable aid in times of major emergencies when customer calls congest regular phones so that they are unavailable for use to key personnel in controlling the emergency.

A most important development in communications has been the mobile phone (Fig. 1). Practical use of these has been limited to large utilities. In addition to providing prompt dispatching of emergency maintenance, the number of time-saving uses of the phones for normal operations is surprising.

Emergency situations caused by breakages in the system from the use of mechanical equipment by all types of construction activity in city streets have greatly increased. In Indianapolis, during 1954, construction work by contractors (primarily on sewer construction) was responsible for 37 main breaks, 85 broken taps, 11 broken service lines for a total 133 emergency situations. Mobile phones, installed in two small trucks, as shown in Fig. 1, and equipped with valve operators, proved their practical necessity for quick control of emergencies and prompt restoration of service.

Transportation Equipment

A third basic tool in the operation of a system is adequate transportation equipment. Most transportation requirements will be satisfied by standard automobiles and trucks providing size and type correlate with their duties. Maintenance and some service trucks may sometimes require custom-built bodies. Compartmented bodies are worth their costs in eliminating lost tools and time spent in searching for misplaced materials. Maintenance trucks should carry sufficient tools, supplies, and repair materials to cover an average job to its completion. Many utilities have installed air compressors in these special bodies. The compressor, as illustrated in Fig. 2, is driven by means of a power takeoff from the truck engine. This eliminates towing a portable generator between jobs.

Valve Operators

Truck-mounted valve operators are displacing the fatiguing and slow hand operation of valves in a system. Such units are driven by the truck motor through a power takeoff. Shear pins are provided in the drive to avoid valve damage and a revolution counter is attached to record valve turns. This unit has proved its usefulness in emergency main shut-offs and in valve-testing programs where manual operation is physically demanding. Indianapolis has two trucks equipped with valve operators mounted on opposite sides of the body. The revolution counters were specially mounted on the instrument panels of the trucks where, as Fig. 1 shows, they are di-

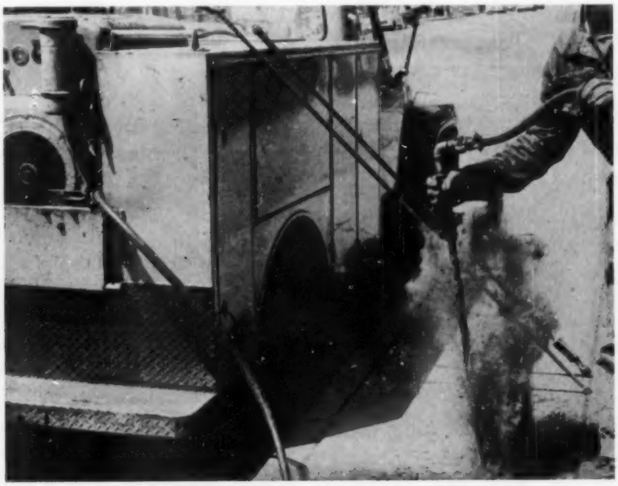

Fig. 4. Air Compressor at Work

This 35-cu ft compressor set in the rear of the truck supplies enough pressure to clean a curb box in a matter of minutes. A shield, normally mounted around the jet pipe to deflect debris to one side, was removed for photographic purposes.

rectly under the operator's eye. These right and left hand mountings have proved quite advantageous in allowing the truck to follow the direction of traffic and still secure access to valves located on both sides of the street. The trucks are also equipped with a special hand hoist that swings out over the same side side as the valve operator to facilitate lifting manhole covers. The hoist, shown in Fig. 3, eliminates many possible injuries involved in manual removal. Only two men are assigned to a valve-operating unit and, in an emergency, one man can operate it. These small trucks are continuously on testing work, yet dispatching them to an emergency creates little disturbance.

Compressed Air

Compressed air is one of the most versatile tools in the maintenance of a distribution system. Primary use of compressed air is for the operation of pavement breakers, but it is also used as a source of power in the operation of clay spades, tampers, calking hammers, sump pumps, pipe saws, sheeting hammers, impact wrenches, portable grinders, tunnel-boring machines, and tapping machines, each of which is a labor-saving tool accessory to a compressor.

The compressed air has its own novel but practical uses. Under favorable conditions (depending on slope of the main and location of hydrants) air can be used to dewater a valved-off section of main quickly by connecting the compressor to one hydrant and discharging from another. Compressed air is also being successfully used to open clogged hydrant drains and service lines rapidly. Debris can be ejected out of valve boxes by jetting with air, although some utilities use water pressure for this purpose. One of the major problems in the customer service division is the large number of clogged service curb boxes encountered. A small portable 35-cu ft compressor, set in the back end of a truck as Fig. 4 shows, has been found to be adequate for air blasting such boxes in matter of minutes.

Moving Equipment

Equipment to handle supplies has many labor-saving possibilities. Storage areas and shops can be designed to eliminate unnecessary movement of material. Storerooms and storage bays of distribution system materials can be built to truck bed height for easy transfer of items to and from trucks. A power crane is necessary to move pipes and heavy fittings from freight cars into storage, and from storage onto trucks. Truck-mounted cranes can do heavy-lift duty over the complete system. A tractor with a front loader is useful in storage yards for quick loading of sand and gravel and on maintenance jobs for loading spoil. Equipped with a hydraulic hoe at the back, this same tractor has dual use in making excavations for maintenance jobs.

Pipeline construction is one phase of distribution system work that can be more fully mechanized than any other. A trenching machine, a crane for pipe handling, suitable backfilling equipment such as a bulldozer, and trucking equipment are primary tools for rapid main-laying work using a minimum of labor. Other mechanical aids should include an air compressor with accessory tools, trench pumps, trench-slushing equipment, and the usual variety of hand tools. The low-boy trailer required for moving heavy

equipment can also make an excellent vehicle for transportation of pipe as Fig. 5 demonstrates.

Pipe and Leak Locators

Annual leak surveys are necessary to prevent water waste and, thus, useless treatment and pumping expenses, and to locate leaks early before damage grows. Such surveys can be conducted quite economically by "listening in" on each hydrant with leak detection equipment at the time of the annual hydrant testing program. The equipment can also be used to spot the exact location of leaks before excavating and to check valve closures to determine source of leakage into a repair job.

Electronic pipe locators are quite useful in locating "lost" or irregularly placed mains and service lines. Subject to interference of other metallic structures and power lines, locators cannot always be used successfully. Magnetic dipping needles should be carried by all personnel having occasion to use valves and service stops.

Miscellaneous Maintenance

The list of miscellaneous tools needed for the efficient operation of a system is a long one. Only some of the more essential items will be noted. Portable generators with floodlights are indispensable for night jobs. Gasoline-powered trench pumps of varying capacities should be available for any job. Bottled gas for melting furnaces has been found to be a source of heat faster than other fuels. Dry ice is proving a much faster method of "freezing" service lines for repairs than the old plain ice and salt method. At least one utility is successfully freezing mains 6-in. and smaller to avoid main shut-offs. Tapping and valve inserting machines can prove economical connections and valve installations in existing mains and can also be used to avoid main shut-offs. Pipe pushers are used by many utilities for pushing service pipes under paved streets.

Materials are not normally classed as tools, unless they are used to reduce maintenance or installation labor. A

Fig. 5. Low-Boy Used as Pipe Hauler

The low-boy is normally used for transporting mechanical equipment. When adapted for use in pipe hauling, it has a capacity of 900 ft of 6-in. Class 150 cast-iron pipe.

good example is the hydrant which breaks off when struck in a collision; emergencies are avoided and repairs are rapidly done with little labor. The mechanical-joint repair sleeve, easily installed under all conditions, is another such material. The use of mechanical joints for all pipeline materials

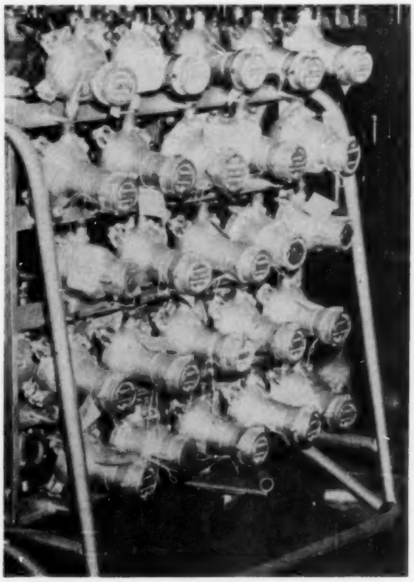

Fig. 6. Meter Storage Rack

This special mobile meter storage rack with a capacity of 50 ⅝-in. meters can also be used for easy movement of meters.

is gaining wide acceptance because of installation advantages. Materials with "O" packing are reducing stuffing box maintenance. Pipe linings are eliminating the corrosion problem, thus further reducing future labor requirements for maintenance. These are but a few of the materials promising greater efficiencies in the future.

Meter Shop Tools

Meter maintenance needs a well designed repair shop equipped with the right tools. Meter maintenance is one of the most important phases of water works operation and needs to receive its just share of attention. The design of the shop should provide easy access for the service trucks and logical movement of meters through the shop in the course of maintenance. Mobile racks of the type shown in Fig. 6, can be used not only for easy movement of meters but for the storage of the meters as well. Handling of meters is decreased when mobile rather than stationary racks are used.

Abrasive blasting of meter exteriors and meter parts is now being given some preference over other cleaning methods. Where painting the exteriors is practiced, the use of spray-guns is more practical than a brush. Multiple testing of meters is faster than single meter testing. Twelve unit benches are used for the ⅝-in. meters and four-unit benches are available for sizes up to 2 in. Test benches are being equipped with automatic shut-off valves which allow accurate testing while testing personnel are released for other duties. Impact wrenches can reduce the dismantling and assembly time of meters, particularly for the larger sizes. Adequate lighting and dust collection are also a part of a well designed shop.

Maintenance Shop

Tools retain their designed usefulness as long as they are adequately serviced and properly maintained. After a new tool is acquired, a procedure is established for its use. Should the tool fail to function, work will be slowed or halted, and man-hours will be wasted until the tool is replaced

or restored to usefulness. A stalled service truck out on the job will not only waste the time of the driver, but add travel time for the garage mechanics. A dull tapping-drill will not only make a tapping job more difficult, but may lead to failure of the drill.

The maintenance shop therefore becomes an important part of total operations and must be equipped with proper tools. Tools that have common use in most shops include a compressor, welding equipment, a hydraulic lift and other hoisting equipment, lubricating equipment, grinders, a drill press, arbor press, motor analyzing equipment, an impact wrench, tire inspection and repair equipment, body repairing tools, painting equipment, and, of course, the many hand tools. Efficiency of shop mechanics will be determined by the adequacy of tools provided for their use.

Safety Tools

The US Department of Labor's report on Injuries and Injury Rates in Water Supply Utilities, 1953 (*1*), shows an upward trend of injury frequency in the water industry. In 1953, the injury rate reached a high comparable with rates in the upper range of those in the manufacturing industries. In light of the subject of this discussion, it is particularly significant that the report shows construction and maintenance of water lines to be more hazardous than any other utility operation: the injury rate is 60 per cent higher than the average for the industry. The report notes that a well administered safety program is an important tool which should have predominant consideration.

Protective shoes, gloves, and hard hats should be worn by all employees handling materials under hazardous conditions. Goggles should be worn for operations such as grinding and pavement breaking. All equipment having moving parts should be properly guarded. Working areas should be kept clean and orderly. An efficient maintenance program is insurance against accidents caused by equipment failures. Barricades, warning signs, red lights, traffic-channeling cones, and other safety devices are, of course, a basic necessity for all street jobs. Trucks that must stand in traffic lanes, such as the valve operating trucks, should be equipped with adequate warning lights which flash. A first-aid room should be provided and if not practicable, first-aid kits should be available to all work areas including maintenance trucks. Above all, personnel must be made safety conscious.

Conclusion

The foregoing list of tools is far from complete and some of the tools mentioned do not have equal use in all utilities, for systems differ in size and method of operation. Each plant operator must give careful consideration to every available tool to fit its practical application to his particular work. In many instances the cost of a new tool may be saved in less than a year's time. If the volume of work to be performed by a tool is insufficient to warrant the cost, or if the cost would impose a financial burden on the utility, the tool should be rented. Should the utility not own sufficient equipment to warrant operation of a maintenance shop, a reliable commercial shop should be engaged to service and maintain equipment.

The plant operator needs to be alert to the ever changing quality of tools. Manufacturers not only develop new tools continuously, but improve the

efficiency and capacities of existing models at the same time. In many cases, replacing a tool because of obsolesence rather than a depreciated condition may be necessary. One should never become complacent about methods and tools. With a little ingenuity tools can often be improvised at little cost and existing tools adapted to new use.

In this respect two examples of experience with tools drawn from the operation of the distribution system in Indianapolis can be mentioned.

In 1930, the water company employed 117 men in two main-laying crews. Most of the main-laying work was done manually except for some trenching. Two crews, working 45 hr a week without vacations, installed a total of 114,000 ft of mains. This represents a productivity of 976 ft per man per year. In 1954, the company employed one crew of 16 that performed all main-laying operations, including pipe hauling. All operations were as fully mechanized as possible. Working 40-hr weeks with a 1–3-week vacation schedule, a total of 51,500 ft of new mains were installed within the year. This was a productivity of 3,300 ft per man. Unit labor costs for 6-in. mains in 1930 averaged 59 cents a foot while in 1954 the comparable cost was only 74 cents a foot, although the wage rate was more than 300 per cent higher than in 1930. The additional charges for mechanical equipment amounted to only 7 cents a foot more in 1954. It should be pointed out that no comparison of this nature can be accurate because construction costs vary considerably with conditions. Length of line has a major bearing on unit costs because of more or less fixed expenses of moving to a job and connecting the extension. The 1954 crews installed 6-in. mains in job lengths over 1,000 ft with an average labor cost of only 38 cents per foot which is considerably under the 1930 figure.

The other example deals with personnel requirements for the operating phase of the system. As stated at the outset, this work is largely a manual job and is not subject to labor savings in any degree comparable to those possible in construction. Tools have nevertheless increased operating efficiencies considerably. In 1930, the company employed an average of one man for each 1,124 m of system for system maintenance, customer services, meter maintenance, maintenance of equipment, and for the clerical work involved. In 1955, the comparable figure was 1,400 m per employee. The difference in work week and vacation allowance must again be considered. Many new work requirements were added in the intervening years so that the comparison does not reflect all the improvement accomplished. It is predicted that the US standard of living in 1975 will be double that of today. With automation only in its initial stage of development, this prediction appears to be quite realistic. We can therefore expect wages and salaries to continue to rise. Water utilities thus have a major tool-application assignment ahead of them if they are to cope with this contemplated progress.

Reference

1. Injury and Injury Rates in Water Supply Utilities. US Dept. of Labor, Washington, D.C. (1953).

Choosing the Proper Valve

J. Harold Whisler

A paper presented on Mar. 21, 1956, at the Illinois Section Meeting, Chicago, Ill., by J. Harold Whisler, Midwest Dist. Mgr. Valve Div., S. Morgan Smith Co., York, Pa.

IN the design of any piping system, there is never a question about the necessity of valving, although there usually is one about the proper valve for the application. Because of advancements in engineering, automation, and manufacturing, proper selection has become more complicated, requiring additional thought and consideration. No other category of mechanical equipment covers a greater variety than that of valves.

The basic types fall into three classes: slide, globe, and rotary. The slide type is one in which the closing element moves perpendicular to, and across the direction of flow as in the gate valve and the sluice gate. The globe type employs an inner disc which seats parallel to the pipeline or direction of flow. (There are many different inner-disc shapes, depending upon the application.) The rotary type has a rotating closing-element supported by trunnions in the valve body. The lubricated plug, butterfly (Fig. 1), ball (Fig. 2), and cone valves (Fig. 3), are examples of this last type.

Valves such as the needle, angle needle, Howell-Bunger, Larner-Johnson, hollow jet, and so on, can be placed in one of the basic classes or a combination thereof. This discussion will be limited to valves used in the water works and sewage industries.

Selection

Points to be considered in the selection of a valve include the following:

Basic application
Operating data
Method of operation
Valve characteristics
Construction
Economics.

Stopping, checking, and regulating are the three basic applications of valves. The stop valve prevents flow beyond the valve, the check prevents flow in the reverse direction (also called the "backflow preventer"), and the regulating valve controls pressure or flow. Basically, any regulating valve is a pressure controller, and one with which a loss of head or pressure is always associated. An *automatic* flow control valve operates by responding to the differential pressure created by flow through a measuring device.

Sometimes attempts are made to combine any two, or possibly all three applications, in one valve. Generally, a combination of only two is practical. For example, a regulating valve could also be a stop valve, or a check valve might be used as a regulating valve. Sometimes a combination of all three may be possible, but the primary reason for installing the valve should be the basic consideration, and any other

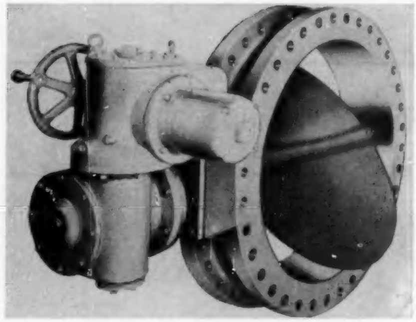

Fig. 1. Manually Operated Butterfly Valve

The gear operator is enclosed, and valve employs angular vane-to-body seating. A rubber seat provides bubble-tight shutoff.

function should be secondary. If the basic valve type will not easily lend itself to the other desired functions, it may be wise to install a second valve.

Operating data should be determined by the designer and should cover the following points:

1. Static pressure
2. Dynamic pressure (flow)
3. Pump shutoff pressure
4. Maximum unbalanced pressure with valve closed
5. Maximum unbalanced pressure for operation of valve
6. Normal flow
7. Maximum flow (emergency)
8. Temperature
9. Allowable leakage
10. Frequency of operation
11. Type of liquid or gas flowing
12. Size and amount of suspended solids (turbidity)
13. Size of line
14. Size of valve.

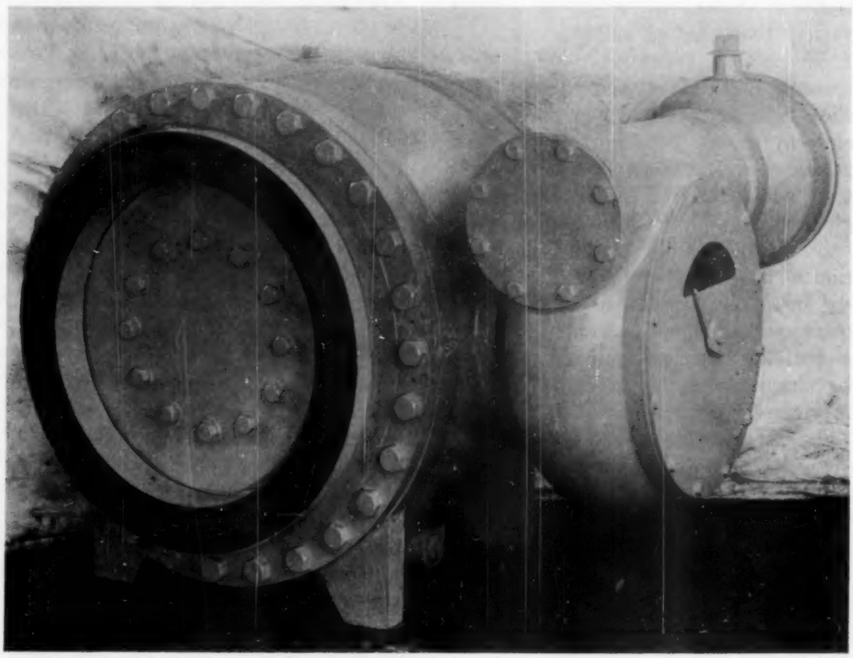

Fig. 2. Ball Valve With Hub Nut

This information is essential if the valve manufacturer is to select the proper class or pressure rating of equipment, and is also important for the final decision on the type of valve to be selected. To determine the allowable leakage and size of valve, it is to the user's advantage to consult a reputable valve manufacturer.

Some valve manufacturers offer a choice in the number of turns for manually operated valves. The user should consult with the manufacturer to determine the various possibilities. Sometimes it is a disadvantage to have a low number of turns, because too rapid closing can cause a serious surge pressure in the pipeline.

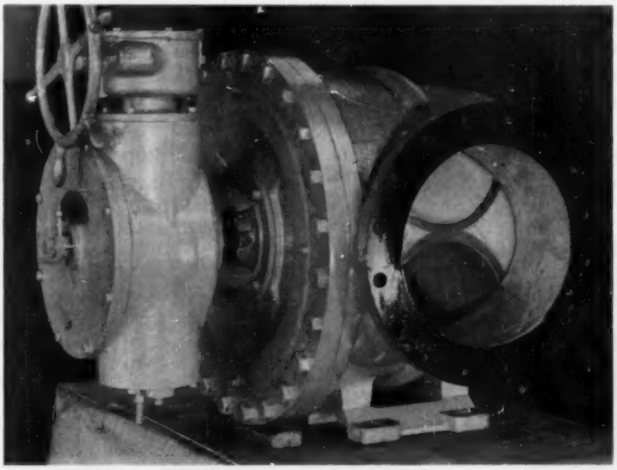

Fig. 3. Manually Operated Rotary Valve of the Cone Plug Type

In partially open position, showing Monel seat rings for open and closed positions.

The methods of operation can be subdivided as follows:

Manual:
- Hand wheel
- Wrench
- Street key

Motor:
- Local manual (pushbutton)
- Remote manual (pushbutton)
- Automatic by signal
- Automatic with manual (pushbutton)
- Auxiliary (manual handwheel)

Cylinder, Diaphragm, or Bellows:
- Hydraulic
- Pneumatic

Standard electric-motor operators are made for both a-c or d-c. The designer should specify the available current characteristics on the original inquiry. Electric-motor operators are particularly useful for operating a valve from a remote location.

Valve operators employing pressure fluid (hydraulic), as shown in Fig. 4, or pressure gas (pneumatic) are also used for remote operation. They are generally used, however, for automatic control. The designer should determine the type of fluid or gas to use and the maximum and minimum pressure available. The operating medium must be clean and available in the

proper quantity. If air is used, the dew point should be given so that proper piston seal can be furnished. The valve manufacturer can be very helpful in this determination.

Characteristics

Probably the most common valve characteristic is head loss, or pressure drop, through one which is wide open. This is especially true of stop or check valves in a pumped system—that is, where the cost of power must always be considered. In this case a valve with a very low head loss is preferable. In a system supplied by gravity, the opposite condition may prevail, in which case it is necessary to introduce a head loss, usually by installation of a pressure-reducing valve.

The ease of operation must be considered if a manual valve is to be operated under emergency conditions such as after a line break. It is important to close the valve quickly in any type of line break, whether in a pumping station, treatment plant, transmission main or distribution system. The valve for this purpose should be one easily operated by one man. In 16-in. sizes and above, the use of rotary valves is an accepted practice.

The more important operating characteristics of a valve are shown in Fig.

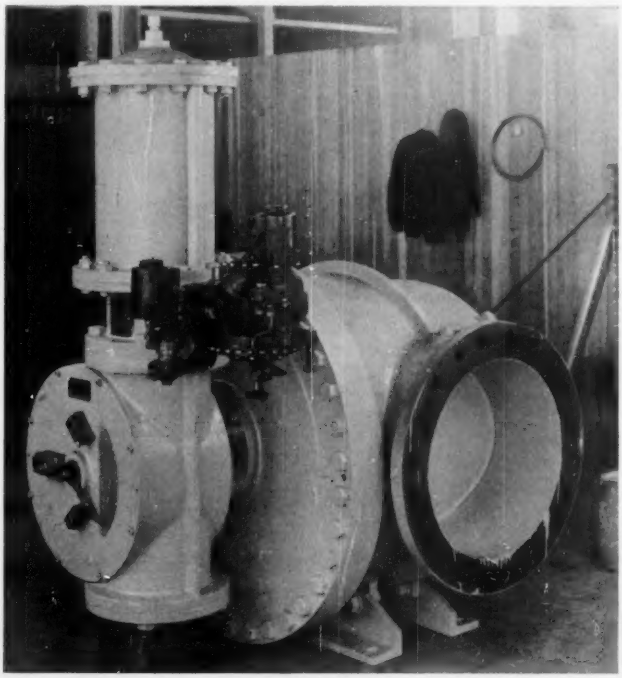

Fig. 4. Hydraulically Operated Rotary Cone Valve

This valve uses either water or oil for its hydraulic operation. The controls shown, are for automatic check service on the electric motor-driven pump.

5 and 6. The relation of area to stroke characteristic (Fig. 5) must be considered in selection of stop and check valves and the relation of stroke to flow characteristic (Fig. 6) is important in selection of regulating valves.

The area-to-stroke relationship is particularly important in stop and check applications where water hammer protection is necessary. From many experiments it has been proved that a valve can be closed to 20 per cent of area in virtually no elapsed time, without creating any serious surge pressure. The critical closing area of any valve is the last 20 per cent. The cone valve curve indicates that 80 per cent of the area is cut off in 40 percentage of the stroke. The remaining 60 per cent of total stroke closes off the last 20 per cent of area and moves the plug axially into the seat. This effect is simply the result of the geometric fact of a circle passing across a circle. The gate and butterfly valves have practically straight-line characteristics and, hence, care should be exercised in operating either of these valves in emergency conditions.

The per cent stroke scale can easily be converted to time and correlated with the water hammer computation to determine the total closing time needed to prevent serious surge pressure. It is recommended that the time for cutting off the last 20 per cent of area be 3–5 times the pipe period (time in which the surge wave traverses the pipeline and returns).

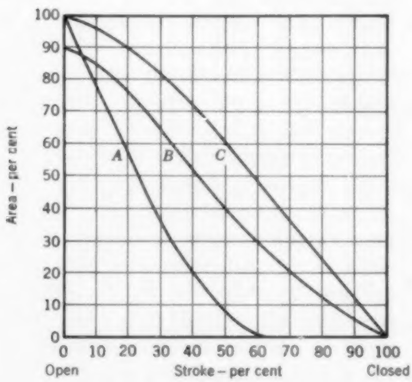

Fig. 5. Relation of Area to Stroke

The curve is plotted to show the characteristics of closing the valve. Percentage is used in order to give a general picture of all sizes. Curves plotted for different sizes would follow the same general shape for each type of valve. Line A is for a cone valve, Line B, for a butterfly, and Line C, a gate valve.

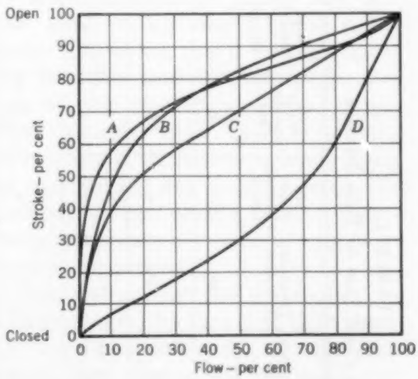

Fig. 6. Relation of Stroke to Flow

The curve shows the characteristics of opening the valve, and is plotted on the basis of a constant pressure drop across the valve. Line A is for a cone valve, Line B represents equal percentage, Line C is for a butterfly valve, and Line D, a quick-opening valve.

The stroke to flow relationship of Fig. 6, plotted in per cent, shows the characteristic of the valve moving from closed to open. Since there are three variables in the equation for flow

TABLE 1

Sample Check Sheet for Valve Selection

Valve	Clean Liquid or Gas	Turbid Liquid	Slurry	Stop	Emergency Stop	Frequent Operation	No Water Hammer Check	Water Hammer Check	High Pressure—No Bypass	Manual Regulation	Automatic Regulation	Free Discharge 50 fps	Tight Shutoff
Gate	x	o	o	x	o	o	o	o	o	o	o	o	x
Square Bottom Gate	x	?	o	x	?	o	o	o	?	x	o	o	x
Quick Opening Globe	x	o	o	x	x	x	x	o	x	o	o	o	x
Characterized Globe	x	o	o	x	x	x	x	?	x	x	x	o	o
Angle Needle	x	x	o	x	x	x	o	o	x	o	o	x	x
Swing Check	x	?	o	x	?	x	x	o	x	o	o	o	?
Butterfly (Rubber Seat)	x	?	o	x	?	x	x	o	x	x	x	o	x
Butterfly (Babbitt Seat)	x	x	o	x	?	x	x	o	x	x	x	?	x
Lubricated Plug	x	x	x	x	?	?	o	o	x	?	o	x	?
Ball	x	o	o	x	x	o	?	?	x	o	o	o	x
Cone	x	x	x	x	x	x	x	x	x	x	x	x	x

x Recommended for requirement.
? Partially suitable.
o Unsuitable.

area, velocity and pressure drop, it is necessary to hold one constant. For convenience, the general practice is to plot the curve on the basis of a constant pressure drop across the valve.

The quick-opening valve, which is generally a globe type with a flat disc and a raised seat, produces a large flow with a small stroke. It is often used for emergency service that requires rapid relieving capacity. It would not be satisfactory for surge relief because the closing characteristic would not prevent the establishment of a secondary surge. The equal-percentage characteristic shows that, regardless of the quantity flowing, at a constant pressure drop, the change in flow is proportional to the rate of flow just before the change occurred, with equal increments of stroke. This is usually considered a good characteristic for general control applications. The globe type valve disc can be characterized to fit any pattern between these two. By plotting the curve on the basis of time in relation to flow, the butterfly characteristic can be changed with a cam positioner attached to the prime mover. The cone valve curve lies very close to the equal-percentage curve and, therefore, has a very good, natural, regulating characteristic.

Rangeability is another characteristic important in the selection of a regulating valve, and will largely determine the size of valve or valves to be used. It is defined as the ratio of maximum controllable flow to minimum controllable flow.

There is a tendency in regulating-valve applications to select a size larger than necessary. The danger involved is that the valve must regulate too near the closed position, or beyond its range. The rangeability of globe and butterfly valves will vary from 5 to 50. An angular-seated butterfly valve will have a greater rangeability than a free-revolving vane butterfly valve. The cone valve has a practical rangeability of 200, and special controls have increased the range to 1,000.

Materials

The materials of which the equipment is made are determined by the type of fluid or gas to be handled, and by the engineering and design practice of the manufacturer. Cast iron and cast steel are no longer simple products. There are many different casting formulas, and the physical properties of cast iron have a wide range. For example, some cast irons now have a tensile strength practically equal to cast steel. For such reasons, the designer or user should ask the manufacturer to state the material specifications in his proposal.

The seating material determines, to a large extent, the time that tight shutoff can be maintained. If seats are metal, they should be of hard and corrosion-resistant materials, such as stainless steel, monel, or manganese bronze. Rubber seats should have good resilience, so that no permanent deformation will take place, yet still be soft enough to effect tight shutoff. For water and sewage service, natural gum rubber is generally recommended.

The packing gland, although a simple part of a valve, often causes considerable trouble. The ease of maintaining and renewing packing is important. The fixed-retainer type using rubber O rings or chevron packing is fairly new, and for valves that are operated frequently, its practicability is doubtful.

The inner, moving elements of a valve, such as bushings, linkages, and

screw stems, are important to the durability of the product. If lubrication is necessary, easily accessible fittings should be provided. The operating mechanism should be one easily maintained and lubricated and, if it is exposed to the flowing fluid or gas, should be designed of materials that will resist corrosion. Many valve failures are caused by improper design and maintenance of the operating mechanism.

The user should check the standard construction offered by each valve manufacturer to determine if any one has some feature especially desirable for use in his system.

Economic Considerations

For any given application, more than one type of valve may be suitable. The problem then becomes one of weighing cost against construction, past history of the valve type, and the reputation of the manufacturer. Quality can never be bought cheaply, and it is well known that the lowest quoted price (first cost) is not always the cheapest. This is true for any item we buy—food, drink, clothing, automobiles, television sets.

No two manufacturers design, produce, and service exactly alike. Any one who has operated mechanical equipment is well aware that it may fail any time after being put into use. The service policy of the manufacturer, written or unwritten, can be the difference between satisfaction and dissatisfaction, and if the manufacturer is liberal in providing free service, this should be considered in any overall evaluation. The service history of a valve type, the manufacturer's experience with this or similar kinds of valves, and his reputation for designing, testing, and servicing, are all economic, although intangible considerations.

Prices are often compared size for size for different types and kinds of valves. It is possible that a higher priced valve in a smaller size will compare favorably with the lower priced valve and do the job better. For example, a choice between a 24-in. butterfly and a 24-in. cone valve for a distribution system, may be made solely on the basis of price. To evaluate the valves properly, however, the conditions of pressure, velocity and possibility of emergency operation should be considered, and the head loss computed. The succeeding step would be to determine the size cone valve that has an equal head loss, and then the next smaller size cone valve, which would, of course, have a slightly greater head loss. (The head loss for the cone valve would have to include the decreaser and increaser sections.) The designer could then compare the initial cost of each with the cost of pumping, and amortize this difference over any period of years desired. This is true economic procedure for final selection.

In addition to the dollar evaluation, some credit should be given to the valve that requires less maintenance and has a good longevity record. A valve should be ranked on the ability to operate under emergency conditions. Many valves of apparently high first cost pay for themselves many times over by preventing damage in an emergency.

Selector Chart

A first step in choosing a valve is the preparation of a selector chart, such as that illustrated in Table 1. The basic requirements may be listed horizontally and the various kinds of

valves listed vertically. Checking in some manner, makes the qualifications of each kind of valve readily apparent.

The chart shown here is rather general. For any particular application, new requirements could be added and some of those indicated, eliminated. As an example, the standard butterfly valve is satisfactory for water with low turbidity, but would not be recommended for continuous high turbidity service without change in the standard construction. The square bottom gate could be used for emergency stop under low pressure, but would not be satisfactory under high pressure.

Additional columns for price and other factors may be added, but, as stated above, the final evaluation should not be based on first cost alone. The differences in design, operation, longevity record, service, and reliability are the intangible qualities on which no dollar value can be placed.

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Kwajalein Island Water System

Francis K. Y. Mau

A contribution to the Journal by Francis K. Y. Mau, San. Engr., Pacific Div., Bureau of Yards and Docks, US Navy, Honolulu, T.H.

KWAJALEIN Island is a flat coral atoll located in the Marshall Islands group. It is 10 air hours away from Honolulu and is at latitude 8°40′N., longitude 167°40′E. The island itself is approximately 2.6 miles long and 0.3 miles wide and is shaped like a boomerang; its area is 0.8 square mile. The average elevation of the island is 7.0 ft and its maximum elevation is 12.0 ft above sea level.

When the Navy assumed control of Kwajalein after World War II, the water supply problem was of primary concern. It was obvious that there were no large dependable ground water or stream supplies. There is, however, considerable rainfall on the island for 8 of the 12 months. Most of the precipitation occurs during squalls and is usually of high intensity and short duration. The mean annual rainfall for Kwajalein, with records dating back to 1945, is 100.05 in. From May through December, the mean rainfall varies from a low of 8.25 in. to a high of 12.05 in. per month. The average rainfall for these eight months is 10.28 in. per month. The average rainfall for the "dry" months of January through April is 4.44 in. per month. It was theorized that if rainfall could be captured and stored during periods of inundation, and then treated and used, the water supply problem would be solved.

The Navy was confronted with supplying sufficient quantities of potable water to support a naval station of about 3,500 people. The only way that a sufficient amount of water could be collected during rainfall periods was by having a catchment area of sufficient size. Underground water collection and storage was impossible owing to the porous condition of the coral. As it was impractical to collect rainfall from all the roof tops and then pipe it to a central storage area, the catchment area for the water supply of the island was constructed utilizing part of the airfield runway.

Source and Storage

The south half of the runway, terminating at approximately the middle of the island, is used as the catchment area. The catchment is sloped toward the center strip of the runway and flows through a 24-in. pipe into a sump. A pump then lifts the water into open concrete storage reservoirs. After completion of the water catchment area, the possibility of phenol and lead contamination from the asphalt paving and gasoline spillage, respectively, was considered by the Medical Department. Monthly water samples have been collected from the open storage tanks since 1953 and none has shown any trace of phenols and lead.

After collection of the rain water from the catchment area, storage facilities are provided in the form of ten 1-mil gal open-top concrete reservoirs in the center of the island. In order

to provide safe, potable water, it was decided that filtration and chlorination were required. Chlorination of water before storage to control algae was also provided, but was later found ineffective and expensive. The treatment facilities consist of pressure filters followed by automatic chlorination. This method was considered the most feasible and practical for the conditions encountered on Kwajalein.

Three pressure filters with a total capacity of 250 gpm are located in the filter house adjacent to the open reservoirs. Two chemical feed pots provided before the filters are being used to feed a polyphosphate for corrosion control. For disinfection of the filtered water, one chlorinating unit with a 24-hr capacity of 15 lb is installed in the filter house.

After final chlorination, the water goes into the distribution system and into a 100,000-gal elevated steel tank floating on the system. This tank is located at the north end, the area of high demand. The south end of the island is now cleared of major structures except for the officers' and chiefs' clubs and the transient barracks. This area has very low water consumption except during fires or emergencies.

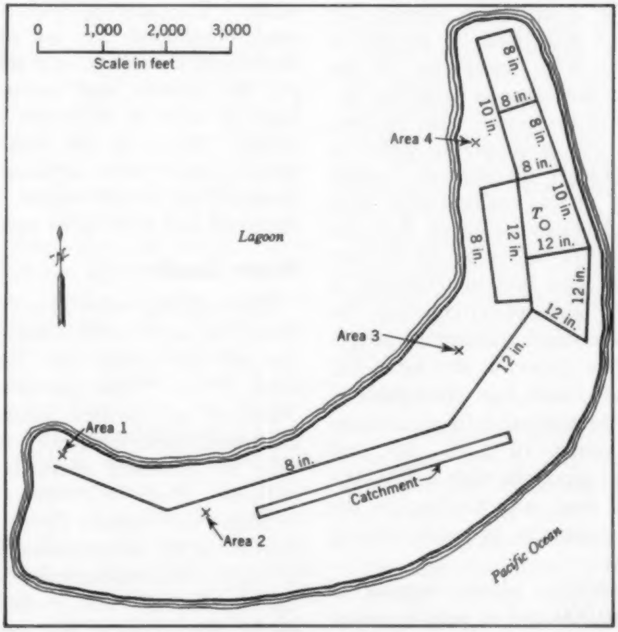

Fig. 1. Water Distribution System, Kwajalein Island.

The system at the north end of the island, which has more than 95 per cent of normal daily consumption, consists of looped pipelines, in sizes indicated, with a 100,000 elevated steel tank, T, *used to maintain pressure during peak periods.*

Until December 1954, however, the terminal and operations building, in-flight mass, transient barracks, some housing, officers' and chiefs' clubs, communications, and the contractors' barracks and offices were still located on the south end of the island.

Distribution

The water distribution system for the island of Kwajalein is shown in Fig. 1. The 8-in. water line on the south end of the island is primarily designed for fire protection with the secondary purpose of supplying water to the few necessary installations located in the area. It was realized that, with such a small consumption on this end of the island, the water would become stagnant, but this was unavoidable in view of the cost of circulating the water and the small number of people affected. The system at the north end of the island, which has more than 95 per cent of the normal daily water consumption, consists of 6-, 8-, 10-, and 12-in. looped pipelines with a 100,000-gal elevated steel tank floating on the system to maintain pressure during peak periods.

Two distillation plants capable of producing 80,000 gpd of potable water from sea water are tied into the distribution system. During extended periods of no rainfall and depleted storage, the island is put on water rations. Water for general distribution is then available only during certain hours and conservation measures are strictly enforced. Water is furnished by the distillation plants before the stored water has reached minimum fire demand. The consumption during normal times is about 80–100 gpcd. With water rations, this amount is reduced to 45 gpcd.

Before completion of the existing water system in 1953, the island was supplied from four water stills. The water was then trucked and pumped to numerous small elevated storage tanks, each serving 1–10 houses. This water was used for drinking and cooking only. Sanitary fixtures and showers were supplied with brackish water. The existing system has, however, eliminated the use of brackish water entirely except as a standby supply for showers and toilets in a few barrack areas in the south end of the island. Most of the small elevated tanks, which were airplane pontoons mounted on a steel tower, have been removed and none is in use.

Water Quality

The existing water system was completed in early 1953, although a portion of the system has been in use since 1952. Water samples collected regularly at various locations were examined bacteriologically and chemically by *Standard Methods* (*1*) procedures. Prior to October 1953, no reliable test results were available. Results of the tests showed water with a high coliform-bacteria and total-bacteria index. The chemical quality of the filtered water has been satisfactory to date. The guide used in determining potability of water is the USPHS Drinking Water Standards (*2*). It should be noted that there were no illnesses traceable to the water supply.

Disinfection

In April 1954, the fresh-water distribution system was flushed and disinfected under the supervision of the author. This was thought necessary because, after the installation of the pipeline in 1953, brackish water was

used for the hydrostatic test without subsequent flushing and disinfection with potable water. The use of brackish water was necessary as there was a water shortage and rationing was in effect. Disinfection was recommended also because jute, which has been known to harbor and act as a medium for the growth of bacteria, was used in the joints of the bell-and-spigot cast-iron pipe.

To minimize inconvenience and interruption to service during the disinfection of the distribution system, all work was done at night. The distribution system was divided into two portions, one north and one south of the filter plant. The south end of the island was done the first night. The north end of the island was valved off at the filter plant and water supplied to consumers from the 100,000 gal stored in the elevated steel tank.

Water for the flushing was taken from the open reservoirs and filtered before use. A superchlorinated water was employed in order to flush and chlorinate the pipelines at the same time. Chlorine was thereby wasted but, during the spring months, water on Kwajalein is more critical than chlorine gas. A minimum of 100-ppm chlorine residual was used in the disinfection. To get the required dosage, the chlorine cylinder was connected directly to the discharge of the filters and a close watch was maintained to assure that the chlorine cylinder pressure was always greater than the pressure in the filters. The direct cylinder connection was necessary because the available chlorinating unit was too small to supply the required dosage. All valves along the pipelines were opened one at a time and water flushed through the fire hydrants until a 100-ppm minimum residual was obtained at all outlets. After 4 hr, the pipeline was drained of the superchlorinated water until a 1.0-ppm residual remained at the end of the line.

The same method of disinfection was applied the following night on the north end of the island. The 100,000-gal elevated steel tank was disinfected at the same time. As water was critical at the time, the superchlorinated water in the elevated tank was not drained before the tank was put back into service. Water containing approximately 20 ppm chlorine was furnished to consumers the first part of the next day with decreasing chlorine residual as the stored water was diluted with low-chlorine-content water. There were several complaints of bad-tasting water, but most people were cooperative and understanding during and after the disinfection of the pipelines.

Surveys

In conjunction with the disinfection, a sanitary survey was conducted and an evaluation of sampling procedures was made. The survey revealed several cross connections between filtered water and untreated rain water from roof tops at old storage tanks. The survey also revealed several needs, such as installation of a standby chlorinating unit at the filter plant, servicing of the existing chlorination equipment, the installation of new gate valves in the distribution system, and the removal of a potential cross connection in the form of a flush-type hydrant on the pier. (The outlet of this hydrant is submerged in surface drain water in a watertight concrete manhole.)

The analysis of sampling procedures resulted in the selection of definite sampling points in the distribution sys-

tem to permit statistical analysis and evaluation of the bacteriological test results. A protective paper cap over the stopper of the sample bottle (to be sterilized at the same time as the bottle) was recommended. Icing samples in the field during collection was also attempted to determine whether the positive samples and high plate counts were caused by the high temperatures at Kwajalein and the elapsed time between sampling and processing in the laboratory. The maximum time required for a sample to reach the laboratory for processing was no more than 2 hr. Icing the water samples after collection had no effect on the coliform-organism test although it tended to produce slightly lower plate counts. It was decided that no appreciable advantage would be gained by icing the sample between the field and laboratory.

Contamination and Preventive Measures

Bacteriological test results on water samples from the distribution system continued to show the presence of coliform organisms after the disinfection in April. In June 1954, two representatives from a naval medical office and the author proceeded to Kwajalein to determine the reason for the persistent positive bacteriological results and high bacterial counts.

Bacteriological samples of water were collected throughout the system to ascertain the area or areas of contamination. The fresh-water distribution system was divided into three major sections with collection points distributed throughout each section in such a manner as to give an overall picture of each. When a positive sample was found, additional samples were collected from the same point and in the immediate vicinity of the positive sample point.

The bacteriological examinations were performed by *Standard Methods* procedures. All samples collected were tested for the presence of coliform organisms and, except in a few instances, for the total number of bacteria in the water. All lactose broth tubes producing a positive reaction were confirmed on both BGB (2 per cent) and EMB agar. The residual chlorine was determined at the time samples were collected. Several sampling points were checked for chlorides and none showed any such unusual amounts of chloride as might have indicated a cross connection between the brackish- and fresh-water systems. After nine days of sampling and testing, results showed four different and separate areas producing unsatisfactory bacteriological results, thus indicating that the condition was not general.

In area No. 1 (quarters area) the contamination was found to be localized in a $\frac{5}{8}$-in. lateral serving only one dwelling. This house was in the process of being vacated and torn down, and the lateral was to be cut off at the 8-in. main. The cause of the unsatisfactory samples was not found, yet it is suspected they were the results of the old lines and low usage rates.

In area No. 2 (in-flight mess area) the problem was unusual, in that, after repeated sampling from seven faucets and spigots, only the two spigots in the scullery produced positive indications of coliform organisms. A chlorine residual in the water from these spigots did not seem to affect the presence of coliform organisms, although it reduced the plate counts. New rubber washers were installed in the spigots but with no improvements

in the results. It was then noticed that on each of the two scullery spigots there was a cloth or cord packing around the riser of the valve stem. New spigots were installed, and the samples collected thereafter proved satisfactory. The plumbers had disposed of the spigots before the packing could be saved for testing. It can be stated conclusively, however, that the contamination was localized in the scullery spigots and was probably caused by packing in the riser of the valve.

In area No. 3 (filter plant), the contamination was found to be centered in the filters. Tests on the raw water showed the presence of coliform organisms; this had been expected, as it was a surface water subject to air and bird pollution. This raw water was being used for backwashing the filters. To prove that the filters were contributing to the positive bacteriological results of the water system, sand samples from two of the three filters were tested before and after backwashing. Each of the four samples tested positive for coliform organisms, with an MPN greater than 39. The surface of the sand in the pressure filters was inspected before backwashing, and a 4-in. mat of dirt and algae was found on the sand bed. Inspection also revealed pockets and bubbles in the sand layer, indicating channeling in the bed. After backwashing, only half the mat was removed. To improve the filter bed condition, the backwash water was chlorinated with a 5.0-ppm chlorine dosage by connecting the prechlorinating unit at a point before the pressure filters. An alternate method of using filtered water from the distribution system was considered and proposed in the event that chlorination of the raw water did not improve the condition of the filter bed. To date, no unsatisfactory water samples have been encountered in the filter plant area.

In area No. 4 (quarters area), the contamination was found to be localized in a lateral serving four barracks. Investigation revealed that the $\frac{3}{4}$-in. lateral serving the area was located at the base of a fire hydrant. Two weeks prior to the investigation there was a break in the 10-in. main supplying the area and no flushing or disinfection was performed after the repair. Sand was later found in a sample collected from the spigot of the barracks. This evidence indicated that sediment which had settled in the fire hydrant line was being washed into the lateral serving the area. From the above findings, it could reasonably be concluded that stagnant and sediment-laden water in the fire hydrant line was being supplied to consumers in this area. After installing a new service lateral off the 10-in. main, no further difficulties were encountered.

Conclusions

The water has been bacteriologically satisfactory since the investigation and recommended alterations to the water system have been completed. The unsatisfactory test results were due to localized contaminated sources which did not affect the water supplied to the major portion of the station. In summary, then:

1. Bacteriological results of water samples collected from October 1953, to June 1954, indicated a questionable quality water.

2. Disinfection of the distribution system did not eliminate the cause of pollution.

3. Further analyses of the water system revealed four isolated areas

where unsatisfactory samples were being collected:

Area No. 1: This quarters area was being razed and the lateral disconnected, thus eliminating the problem.

Area No. 2: In this in-flight mess area, the cause of contamination was eliminated by changing the spigots at the sampling points.

Area No. 3: The problem in the filter plant area was found to be caused by the backwash water and filter beds. Cleaning the sand bed and chlorinating the backwash water resolved the problem.

Area No. 4: In this quarters area the problem was caused by improper location of the service lateral connection. Relocating the lateral eliminated the problem.

4. The remainder of the island was found to have satisfactory water, meeting all the requirements of USPHS Drinking Water Standards (*2*).

5. There have been no problems with contaminated water since the completion of the investigation and recommended alterations to the water system.

Acknowledgements

The opinions and assertions herein are those of the author and cannot be construed as representing the views of the Navy Department or the Naval Service at large. The use of commercially available products does not imply their endorsement or preference of the products of one manufacturer over similar products which are or may become available from other manufacturers.

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Soil Mechanics and Backfilling Practices

Henry M. Reitz

A paper presented on May 10, 1956, at the Diamond Jubilee Conference, St. Louis, Mo., by Henry M. Reitz, Prof., Dept. of Civ. Eng., Washington Univ., St. Louis, Mo.

ONE common field in which basic information on soil types and properties is invaluable is that of underground utility installation. In all instances this work requires excavating the soil, placing the utility, and backfilling. The many different problems that enter into this practice include the stability of the side of the trench during the excavation (as a cost item as well as a safety item), and the satisfactory placement of backfill so that the filled-soil characteristics are comparable to those of the adjacent undisturbed soil.

Soil Types

Soils may be divided into two general classifications: cohesionless and cohesive. The former, more commonly known as "sandy" or "gravelly" soil, is described primarily by the type of particle of which it is composed—the *bulky* particle—in which the ratio of surface area to mass is very low. This ratio is called "specific surface" and is an easy way to differentiate the two major groups of soil particles. The shape of the soil particle is also important, and this ranges from the almost perfect sphere to the very angular polyhedron, or from the glacial-type sand or gravel to the crushed aggregate (commonly crushed bed rock). The size range, in general, is described in decreasing diameter as boulder, cobble, gravel, sand, and, possibly, silt Not only the range of size of the particles, but the grading of one size into another is quite important in conveying the properties of granular material. Gradation characteristics, therefore, are essential to a complete description.

It is important to remember when discussing cohesionless soils that the particles involved are the result of mechanical breakdown such as occurs when large rocks are reduced, by crushing, to smaller ones. Mechanical breakdown is typical of weathering processes which result from expansion and contraction caused by variations in temperature, or wetting and drying, and from the wedging action of ice in cracks or that of plant roots reaching downward through a rock mass.

Cohesive soils, in contrast with the bulky particles of cohesionless soil, are composed of significant amounts of so-called *platy* particles. The platy particle, sometimes given the name "flaky," is characteristic of the clay minerals, and the sizes are referred to as "clay" or "colloid." It has a high surface-to-mass ratio and accordingly has a high specific surface. It also displays plasticity, that most characteristic property of cohesive material, which is the ability of a soil to be rapidly deformed without volume change and without cracking, crumbling, or elastic rebound. Plasticity arises partly from the platy nature of the particle, since, relative to the bulky

particle, there is much more surface, hence much greater opportunity for phenomena which depend upon the interaction of water with the particle surface.

The platy particle is the result of *chemical* weathering as contrasted with *mechanical* weathering. Chemical weathering is made possible by the high amount of surface area or specific surface, which allows the agents of chemical breakdown (atmosphere and moisture) to act upon the minerals in the particle. Chemical weathering changes the constitution of the minerals as well as the size and shape, and mechanical weathering affects only the latter. It is worth repeating that these platy particles make up clayey minerals in general and, although particles of similar appearance do occur in larger minerals such as mica or isinglass, they are almost wholly restricted to clay size or finer. The characteristic magnitude of such particles is about 1 μ or roughly 0.00004 in.

Sands, silts, and clays constitute the three general soil subdivisions. The extremes of classification, sand and clay—coarsest and finest—are quite clear-cut, and have already been described. Inasmuch as some silts (the intermediate classification) act as very fine sands while others act as clays, considerable trouble can result from misidentifying plastic and nonplastic silts. There is, of course, a great deal of difference between the action of a true clay and that of a sand—especially a fine sand—in the presence of water.

Significant Properties

Soil properties of interest in trenching operations are, generally, strength, volume change characteristics, permeability by water, and elasticity, or "modulus of deformation." Of primary importance as a control item which greatly influences all of these properties is the density of the soil. This is a property which can quite easily be checked in field operations, the property investigated being compared with it or with the moisture content which accompanies it.

In practice, density is computed as the weight of solids per unit volume in a dry condition. (The solids form the structure that affects the variable properties.) This is done because it is possible to have the same wet density (weight of soils plus water) at two different moisture contents with a different dry density.

Since these variable properties are related to density, it is important to discuss the manner in which densities are affected by various laboratory means of densification as well as by field methods that parallel those of the laboratory.

Densification Methods

In general, bulky particles act as individual grains. To achieve a stable situation, it is necessary that each particle be in contact with all its neighbors. Hence, any structure with a loose arrangement of bulky particles is unstable and will tend to be reduced in volume and become more stable. The greatest aid to reducing the instability is vibration of the mass. The greatest deterrent to the effectiveness of vibration is a partially saturated soil in which a small moisture film acts as temporary glue, delaying the settling process. As a result, the most satisfactory way to densify bulky particles is by vibration in the absence of water films. It appears that the easiest way to dispose of any water film is to dry the soil, but this is practical only under very unusual conditions. Con-

sequently, the best way to destroy a water film is to drown it out, making vibration in an inundated condition the most effective means of densifying bulky soils.

Soils containing platy particles display attractive forces between particles and these forces tend to hold the particles in position. These cohesive forces act to decrease the effectiveness of vibration. The best way to overcome a loose structure in cohesive soil is to break it down under applied load. The general method, therefore, for densifying soils with platy particles—that is, plastic soils—is by static pressure or, more economically, by dynamic pressure from a repeatedly applied load. Although it is not implied that water is unimportant in densifying the clayey soils, the process of densification, commonly termed compaction, is one in which unlimited water is not beneficial. Water influences compaction in several different ways, and as a result, its function cannot be as simply explained as it is in cohesionless material.

In field practice, the cheapest and simplest backfilling method consists of loose dumping or pushing a pile of excavated material into the ditch. Another method in frequent use is flushing or jetting of trenches filled by dumping. One that requires more care, and therefore more cost, is the hand-tamping method, employing either entirely manual or pneumatic techniques (which require some manual control). There are other compaction methods in which gasoline-powered equipment with a pogo-stick

TABLE 1

Relation of Soil Density to Densification Method

Characteristics	Soil Samples*					
	A	B	C	D	E	F
Liquid limit	54.0	57.0	48.0	37.0	34.0	36.0
Plastic limit	17.0	25.0	20.1	16.5	19.0	26.5
MDW†—*lb/cu ft*	99.0	96.5	99.1	106.3	108.5	104.0
Optimum moisture—%	21.0	24.0	24.5	18.8	17.0	17.0
Moisture content at start —%	27.3	7.7	19.6	25.0	32.6	13.5
Densification Method	**Soil Density—% MDW**					
Loosely packed	55.0	71.6	50.5	42.8	57.5	70.1
Inundated	55.0	79.0	51.6	44.4	58.8	86.4
Inundated and loaded with 150 psf	67.5			52.0	72.5	
Inundated and loaded with 300 psf	71.5	86.6	85.0	62.5	78.0	92.1
Loaded with 600 psf	75.7		90.5	73.5	84.0	
Loaded with 1,200 psf	83.0		97.0	84.0	88.0	

* Data for samples A, B, and F are averages of three tests each. Data for samples D and E are averages of two tests each.

† Maximum dry unit weight for standard compaction (0.033-cu ft mold, 3 layers; 25 blows per layer with 5.5-lb hammer, 12-in fall).

action performs the tamping, and some, employing vibration, which are in the experimental stage. One further method that completely bypasses all the preceding, and avoids the expense of densifying plastic soils, consists in replacing the excavated material with a granular fill.

Evaluations of the effectiveness of inundation and static load are listed in Table 1, in which laboratory methods that correspond to the field methods are used, and relative densities which result from various methods of densification shown. Note that loose dumping corresponds to practically no densification. Flushing or jetting is comparable to inundation with some minor vibrating. Constantly moving the jet pipe gives good results in densifying cohesionless soils. Hand and other methods of tamping approach the static or dynamic compaction methods which are practical for cohesive soil. In the granular-fill method, of course, the fill is inundated or vibrated to a satisfactory density.

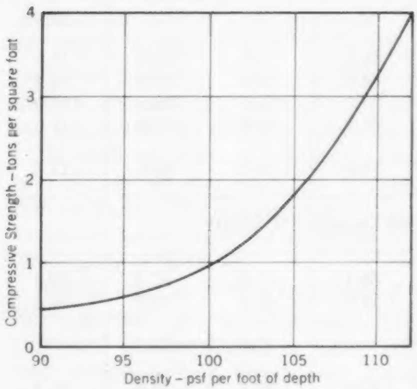

Fig. 1. Relation of Compressive Strength to Density

Strengths shown are for the natural gradation of the sample.

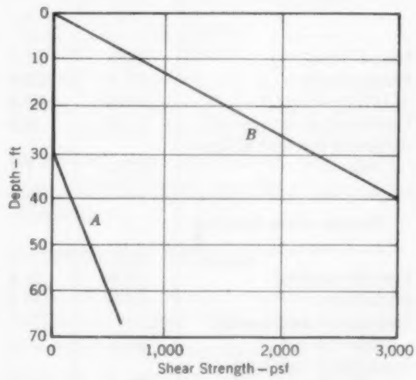

Fig. 2. Relation of Shear Strength to Depth of Fill

Line A *shows relationships for fine-grained (platy) particles, Line* B *for coarse-grained (bulky) particles. Samples were taken from different parts of the same hydraulically placed fill.*

There is a marked difference in effectiveness between flushing a cohesionless soil and flushing a plastic soil. Although both plastic soils and nonplastic soils can be satisfactorily compacted by tamping, the energy and cost expended are less effective with cohesionless material. It is not, therefore, a recommended approach for that type of material. This is similar to saying that a sheepfoot roller may be used on a sand fill, but that the roller would probably be more effective empty than loaded.

Sample Study

A specific example may help illustrate the difference in behavior of the coarse-grain and fine-grain soils. Recently, the opportunity arose to deter-

mine the variation in properties in different portions of a hydraulically placed fill. The parent material was a silty loess, and the disturbed material a sandy, clayey silt of low plasticity. The unconfined compressive strength had been determined for controlled earth embankments confining the fill. The relation of compressive strength to density is indicated in Fig. 1. The great increase in strength at densities in excess of 105 psf per foot of depth would be even more marked if this material were coarser. It should be noted that the strengths in Fig. 1 are for the natural gradation of the sample.

The shear strengths in different portions of the fill deposited by hydraulic means show the extreme difference for the coarse- and fine-grained particles. This is shown in Fig. 2. It should be noted that the mixture of fill and transporting water was discharged from a pipe along one edge of the embankment. The coarse-grained material, larger in size, settled out very rapidly, while the fine-grained, which was carried to the most remote portion of the fill, settled out very slowly. The fine-grained material showed no measurable strength, until a depth of 30 ft had been exceeded. At this depth, the coarse-grained material had a shear strength of approximately 2,500 psf. This corresponds to approximately half the unconfined compressive strength shown in Fig. 1. Equally important is the great increase in shear strength with depth for the coarse-grained as compared to the fine-grained materials. This increase is about 70 psf per foot of depth for the coarse-grained soil from the surface down as compared with 17 psf per foot of depth for the fine-grained soil, starting only after a depth of 30 ft had been reached. It should be quite obvious that, at best, this fill material is normally consolidated or consolidated only under its own weight. In the case of the fine-grained portion, it would not have reached even this degree, but would be only a partially consolidated deposit. Fig. 2 demonstrates the difference in strength for coarse-grained and fine-grained materials excavated and transported by the same methods. The only difference is in the settling rate, a function of size. The coarse-grained structure would be single grained and the fine-grained structure would be a flocculant type which is very loose and fluffy.

Examples in which this variation in strength would be directly applicable to trenching operations are the following:

1. The familiar problem of anchorage at bends, in which the strength of the soil directly affects its ability to withstand thrust.

2. The question of the ability of the sides of a ditch to stand as excavated. (This deals more with virgin-soil structure than backfill.) On this point there is an apparent contradiction, in that cohesive materials, even at low densities, may have greater ability to stand at steep inclination than dense, cohesionless material. In general, a cohesionless material at a slope approaching 45 deg off the horizontal is at its steepest possible inclination but cohesive materials can stand in vertical or overhanging faces. The possible unsupported height increases directly with an increase in shear strength. However, the height of a granular slope is not limited.

3. The load-supporting capacity is also very important. In general, most settlement is a result of the inability of a soil to support its own overburden. This is visible primarily as settlement

in a backfilled ditch and can best be avoided by initially placing the backfill at a high density.

Suitability of Method

In general, the characteristics of the soil which best indicate suitability of densifying methods are the limits established in 1930 by Atterberg. These are descriptive of the plasticity characteristic and those of primary interest are, namely, the liquid limit, the plastic limit, and the plasticity index, which is the range between these two limits. All limits are moisture contents, and can briefly be explained by stating that, within the range between the liquid and plastic limit, the soil may be manipulated, remolded, or otherwise worked, and will display the properties of plasticity. The most important plastic property of the soil is not the magnitude of the liquid limit alone, but rather the plasticity index in conjunction with the liquid limit.

Table 1 is a summary of different types of soil densified by various methods. It is generally indicated that the lower the liquid limit, and the smaller the range between the liquid limit and plastic limit, the greater the effectiveness of inundation; the higher the liquid limit, the greater the necessity for static or dynamic compaction methods. Although there is no general agreement as to what minimum percentage of maximum dry unit weight is acceptable in field operation (because the lower limit of acceptability varies with the type of soil and situation), it is worth pointing out that, in general, highway specifications guided by the American Association of State Highway Officials indicate densities of 90–95 per cent of the laboratory control as the lower acceptable level for fills where strength and reasonable freedom from differential settlement are important. This figure may be somewhat high; densities as low as 85 per cent are acceptable in some control conditions. In uncontrolled conditions this figure might even drop to 80 per cent. For such situations as subbases or rigid airport pavements, the level of acceptability, in terms of the control stated above, may rise to as much as 110 per cent.

The cost of placing dense backfill is not low in any locality, because the restricted working space prevents the use of the large-size equipment which would normally produce the outstanding economies associated with earth-handling equipment. In many localities, the cost of buying and placing granular fill (which is composed entirely of bulky particles), and the freedom from subsequent volume change, with the associated high strengths, dictate that fill be imported where any severe requirements are placed upon the ground surface. In other places the densification may be achieved by some other relatively effective method.

The foregoing has been an effort to present the cardinal properties of soil particles and resulting soil structures which influence the cost and suitability of different methods of backfilling trenches so that the backfill will be comparable to or better than the material it replaced. The emphasis has been on the influence of methods of backfilling and densification as they affect soil properties. The density is chosen because it is a very easily determined characteristic, and its variation is reflected in the variation of those important soil properties such as strength, freedom from additional densification under natural forces, watertightness, and many other related characteristics.

Effect of Highly Chlorinated Drinking Water on White Mice

Carl J. Blabaum and M. Starr Nichols

A contribution to the Journal by C. J. Blabaum, Research Asst., San. Eng. Lab., Univ. of Wisconsin, Madison, Wis., and M. Starr Nichols, Asst. Director, State Lab. of Hygiene, Univ. of Wisconsin, Madison, Wis.

THERE is very little information in water treatment literature on the effect on animals of high chlorine residuals in drinking water. Muegge (*1*) has reported on the physiological effects of heavy chlorination, and some information may be derived from the use, during World War I, of Dakin's solution which contained 0.4–0.6% sodium hypochlorite (equivalent to approximately 4,000–6,000 ppm free available chlorine) for irrigating wounds (*2*). Goodman and Gilman (*3*) report that chlorine gas in air is detectable in a concentration of 1 part in 100,000, that 1 part of chlorine in 10,000 parts of air produces marked irritation of the respiratory tract, and that a concentration of 1 part per 1,000 is fatal if breathed for 5 min. Hudson (*4*) and Metzler (*5*) report that dosages of 50–90 ppm in drinking water have been used by man for short periods of time without any known adverse effects. There are several other instances in which drinking water containing 50 ppm or more was used for short periods without known adverse effects on imbibers.

Experimental Conditions

The chlorine concentrations used in experiments reported herein were 100 and 200 ppm in the drinking water of white mice. The mice were from the colony maintained for virus studies at the Wisconsin State Laboratory of Hygiene. All of the mice used in the 100 ppm work were weaned for about one week before they were started on the highly chlorinated water, and were within plus or minus five days of the same age.

A stock solution of chlorine was prepared by bubbling chlorine gas through Madison city water. The analysis of this water is given in Table 1.

TABLE 1

Partial Analysis of Madison City Water

Item	Amount *ppm*
Alkalinity, as $CaCO_3$	296
Calcium, as Ca	68
Magnesium, as Mg	36
Chlorides, as Cl	10
Sulfates, as SO_4	13
Total solids	310
pH	7.3

Chlorine in water produces acids in the following reaction:

$$Cl_2 + H_2O \rightarrow HCl + HOCl$$

Basic substances in natural waters react with the released hydrogen ions to buffer the reaction. The alkalinity of Madison city water was such that the pH of the water containing 100 ppm of free available chlorine ranged from 6.2 to 6.5, and, for the water containing 200 ppm, from 5.9 to 6.2.

Chlorine residuals were determined at 12-hr intervals for the freshly prepared chlorine drinking water and also for that which remained in the watering device from which the mice drank during the previous 12 hours. All of the chlorinated drinking waters used were prepared from the stock solution mentioned and adjusted to the required strength. The iodometric method (*6*) was used to determine chlorine concentrations.

Procedure

During the experiments the animals were kept in screen-covered, cylindrical glass jars, each 8 in. in diameter and 8 in. high. Raised screen floors were used during those studies in which a concentration of 200 ppm of free available chlorine was present in the water. A maximum of ten mice were kept in a single jar. The mice were fed a completely balanced, commercial ration. The watering device was a glass bottle fitted with a rubber stopper and glass tube as shown in Fig. 1, and had a capacity of 110 ml. The device dispensed water drop by drop as the mice drank, and checks with the use of chlorine test papers showed that the chlorine content of the drop was not appreciably different from that in the bottle.

The first part of the work was done with two groups of ten mice each. One group received water containing 100 ppm of free available chlorine as its sole water supply, and this water was available at all times. The second group was used as a control and Madison city water was the only water given to it. In the second part of the experiment, the free available chlorine was increased to 200 ppm in the sole water supply of two groups of ten mice each—one group female, and the other male, and both recently weaned. The controls for the first part of the work served as controls for the second.

As the chlorine water was used by the mice and as bubbles of air entered the bottle reservoirs, there was some concern that the concentration of free available chlorine would not remain at the starting value after 12 hr in the reservoirs. The concentration values of Table 2 were picked at random and are typical of those found.

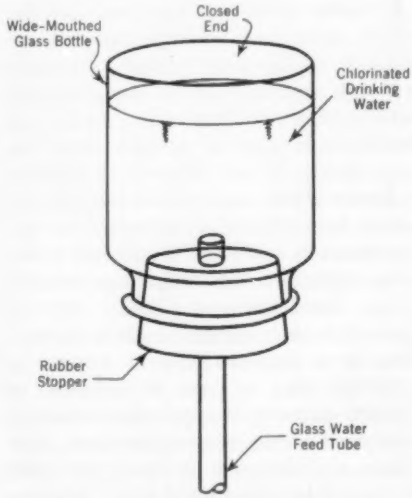

Fig. 1. Watering Device Used in Experiment

The experiment using 100 ppm of free available chlorine in drinking water continued for 50 days. The mice used were all males, and 10 days after the beginning of the experiment had an average weight of 20.3 g. At the end of the experiment, the mice using chlorinated (100 ppm) water had an average weight of 25.6 g, and the control group had an average weight of 25.5 g. Individual weight of mice showed very little variation from this average. The experiment using 200 ppm free available chlorine in the

drinking water continued for 33 days. Female mice at the beginning weighed 16.2 g, and at the end weighed 20.7 g. The male mice at the start weighed 19.3 g, and at the end of 33 days weighed 25.6 g. Here again, weights of individual mice in each group were close to the average.

Mice in all groups drank an average of about 2.5 ml of water per mouse per day as observed from depletion of the supply in the glass bottle reservoirs. There was no measurable difference in the amount of water consumed by either the controls or the three experimental groups drinking chlorinated water.

TABLE 2

Variation of Concentration of Chlorine

Date	100-ppm Sample—*ppm*		200-ppm Sample—*ppm*	
	At Start	After 12 hr	At Start	After 12 hr
Apr. 18	107	86		
Apr. 19	109	94		
Apr. 30	107	98	M 210	184
			F 210	192
May 10	109	99	M 210	197
			F 210	199
May 15	112	96	M 213	203
			F 213	204
May 25	106	99	M 207	199
			F 207	199

* M—water imbibed by male mice; F—water imbibed by female mice.

At the end of these experiments, the mice were killed with chloroform and an autopsy made. Their internal organs were exposed, and the stomachs, intestines, kidneys, livers and spleens of the mice consuming the chlorinated water were compared with those of the controls. All of the mice were fat and sleek, displaying "rolls" of fat inside the abdominal cavity, near the kidneys, and in the mesenteries. Stomachs of all the mice were filled with food, and no defects were found in any of their organs. All of the 30 mice using chlorinated water and six of the controls were thus examined. Histological sections were obtained from both ends of the stomach. Sections were also taken from the other organs mentioned. These tissues were fixed in formalin, stained with hematoxylin-eosin and examined by Anton Lindner, pathologist of the Wisconsin State Laboratory of Hygiene. Lindner's examination showed no pathological or histological changes in any of these tissues.

Conclusion

These experiments show conclusively that white mice can grow to adulthood from weanlings and thrive on water containing 200 ppm free available chlorine. Two groups of white mice on standard dry diet drank nothing but water containing 200 ppm free available chlorine, and at autopsy showed no gross lesions. Histological examination of stained sections by microscopic methods showed no abnormality.

One group of white mice on standard dry diet drank nothing but water containing 100 ppm free available chlorine for 50 days, and at autopsy showed no pathology by either gross observation or by microscopic examination.

Weight gain and growth of recently weaned mice, on standard dry diet, drinking only water containing either 100 ppm or 200 ppm free available chlorine, were equal to the controls used. All animals at autopsy were normal in every respect.

Acknowledgment

The authors wish to thank O. J. Muegge, State Sanitary Engineer, for

suggesting this experiment and G. A. Rohlich of the Sanitary Engineering Laboratory of the University of Wisconsin for suggestions and advice in carrying out the work.

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Accidental Ingestion of Chlorine

On Oct. 19, 1955, a 4-year-old boy who resided at a trailer court near Madison, Wis., swallowed a dose of full-strength bleach. He apparently swallowed one or two mouthfuls of bleach which he had found in a glass placed on the sink. Immediately following the ingestion he was given milk which he did not vomit, and was rushed to a hospital where his stomach was pumped out. The attending physician said that there seemed to be no harmful effects. The boy had a poor appetite for a few days and was rather pale. He took achromycin syrup for 4 days, four times daily. Seventeen days after the event, the boy's mother stated that he seemed to have suffered no ill effects, and, in fact, had not tasted the bleach while swallowing it. His appetite was excellent.

Physiological Effects of Heavily Chlorinated Drinking Water

Oswald J. Muegge

A contribution to the Journal by Oswald J. Muegge, State San. Engr., State Board of Health, Madison, Wis. The paper was prepared as a progress report for the Subcommittee on Water Supply of the Committee on San. Eng. & Environment, National Academy of Sciences, National Research Council, Washington, D.C., and was approved by the committee on Dec. 14, 1954.

A RATHER detailed search has disclosed little information pertaining to physiological effects of higher-than-normal dosages of chlorine in drinking water. Some authorities have indicated that a toxic reaction to chlorine in customary disinfection concentrations would be improbable because of the high hydrochloric acid content of gastric juices. Nearly all persons with whom the matter was discussed have expressed the opinion that the chlorine concentration in drinking water at the point of refusal would certainly be below the concentration producing adverse physiological effects.

Experience with chlorination in normal water works practice indicates that the objectionable concentration varies with the individual, the type of water, and the temperature. Some react to very low concentrations, beginning with detectable free chlorine residuals, while others are tolerant to the highest concentrations used in water works practice. Experimental work in this area discloses that the point of refusal of the majority of people would occur before the chlorine residual reached 25 ppm but that some would tolerate dosages as high as 50 ppm (*1, 2*). It is to be anticipated that in time of stress, such as during disaster, the point of refusal, if it is reached, would be at higher concentration levels than those otherwise tolerated.

In medical practice, relatively high chlorine concentrations are beneficially used, as in Dakin's solution, with a chlorine content of 4,300 to 4,800 ppm for wound irrigation, and chloramine T solutions (sodium *p*-toluene-sulfonchloramide) with chlorine content of 120, 240 and 300 ppm for eye, nose and throat, and bladder irrigation, respectively (*3*). It has also been reported that in earlier times, typhoid fever patients were treated with hypochlorite to the amount necessary to produce a chlorine odor in the feces.

Experimental Data

Experimental work on toxic concentrations of chlorine appears to be extremely limited. Marks (*4*) reports that 490 ml of trichloromelamine (92 per cent titratable chlorine) per kilogram of body weight of mice was lethal. Chronic toxicity studies on rats using as much as 1,000 ppm of the chloromelamine in the diet produced no significant effect during a 14-month period. The concentrations used in these studies provide a greater chlorine concentration than those that

would be expected in water treatment practice.

The physiological response to chlorine in the atmosphere has been established. The accepted limiting values in air are given in Table 1, and may be correlated with concentrations in water on the basis of total intake and on the assumption that the effect of chlorine is apt to be similar whether the tissues affected are those of the respiratory tract or the alimentary canal. For the purpose of making such correlation, a 40-ppm chlorine concentration in air, a short exposure period of 12 min, and a normal air intake of 21 liters per minute were selected. In such situations the total chlorine intake would be 32 mg. The same amount of chlorine would be contained in 0.25 liter of water having a chlorine concentration of 128 ppm—0.25 liter being a likely intake of water.

TABLE 1

Limiting Values for Chlorine in the Atmosphere

	Concentrations in Air	
	ppm	*mg/l*
Permissible 8-hr working exposure	1.0	0.003
Least detectable odor	3.5	0.011
Minimum causing throat irritation	15.1	0.048
Minimum causing coughing	30.2	0.096
Maximum for short exposure	40.0	0.127
Dangerous for even short exposure	40–60	0.127–0.190
Rapidly fatal	1,000	3.16

High Chlorine Dosages

Chlorine, in relatively high concentrations of from 50 to 200 ppm, has been used extensively for disinfection of water wells, mains, and storage units following repair or reconstruction. Occasionally, reports are received that the water is used during such periods for drinking and domestic purposes. At no time, however, have such reports indicated that the high chlorine concentration has resulted in distress to the consumers. Typical of such occurrences is the report by Lowe (*6*) that at the time of main disinfection at Fort Bragg, over 150 persons regularly used the water with a chlorine content of 50 ppm. The greatest objection to the chlorinated water came from personnel using the showers.

High chlorine concentration has also been used to reduce the hazard to health resulting from flooding of water works systems. Hudson (*7*) reports that 50 ppm was used in the distribution system at Golconda, Ill., during the Ohio River flood of 1937. He observed that many residents continued use of the water even though other drinking water was available. No adverse reaction was reported. Metzler (*8*) reports that after the 1951 flood on the Kansas River, chlorine residuals as high as 90 ppm were carried in the distribution system of North Lawrence, Kans. Residents drank the highly chlorinated water, with no known adverse effects, although test records showing many residuals of 50 ppm or more. None of the consumers complained of chlorinous taste, and physicians contacted had no knowledge of adverse reactions.

Use of water with high chlorine residuals at overseas stations has been reported by armed forces personnel. In one case, water with 32 ppm of residual chlorine was used by a group of 200 persons for several months without any adverse effects. Complaints of objectionable taste were received and most of the group tried to get other water. In other cases, water with 15–25 ppm of free chlorine was used for shorter periods of time without physical distress. Water with a free chlorine residual of 5 ppm has

been used by the Army (*9*) in Korea for a prolonged period, while the Navy (*10*) has used 6-ppm residuals on small harbor craft drawing water from unapproved sources. No serious objection has been raised to such residuals.

Scott (*11*) reports the occurrence of illness among Army personnel which resulted from an accidental overdose of chlorine in drinking water. Presumably, because of hurried consumption of the treated water, a strong chlorine odor went unnoticed. Constriction of the throat, momentary strangulation, and irritation of the membranes of the throat and mouth resulted. The chlorine level, determined by a field laboratory by titration of a sample collected several hours after the incident, was 90 ppm. In all probability the concentration was materially higher at the time of use.

Strange and his associates (*12*) report that a 49-year-old individual, in an attempted suicide, drank about a quart of "Clorox" household bleach containing 50,000 ppm chlorine. The stomach was severely damaged, although there was no apparent injury to the esophagus, and the individual recovered after medical treatment.

The facts indicate that human beings have a substantial degree of tolerance for highly chlorinated water. Further experimentation to determine the extent of tolerance and any adverse physiological effects is recommended.

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Recommended Chlorine Residuals for Military Water Supplies

W. Brewster Snow

A contribution to the Journal by W. Brewster Snow, Chairman, Dept. of Civ. Eng., Rutgers University, New Brunswick, N.J. The paper was prepared as a report for the Subcommittee on Water Supply of the Committee on San. Eng. & Environment, National Academy of Sciences, National Research Council, Washington, D.C., and was approved by the committee on Dec. 14, 1954.

IN general, six major variables have been shown to affect the efficacy of chlorine disinfection: (1) the types and concentrations of the chlorine present; (2) the equilibrium relationships between coexistent chlorine forms (governed largely by the pH of the water); (3) the type and density of organisms (virus, bacteria, protozoa, helminth, and other forms) and their species resistivity to chlorine; (4) the duration of contact of the organisms with the chlorine; (5) the temperature of the water, insofar as it determines the rate of reaction of chlorine compounds and the rate of kill of organisms; and (6) the concentration of substances whose rapid oxidation by chlorine is manifested as chlorine demand.

Experimental data are not sufficient to provide specification of the chlorine concentration required for kill for all conceivable values of each of these variables, and so many variables cannot be represented on a single chart. The following simplifications, adopted to reduce the number of variables to be treated, form the basis of the accompanying charts:

1. It is generally accepted that, of the waterborne diseases, those whose causative organisms are bacteria are the most readily susceptible to chlorine disinfection. On the other hand, the cysts of *Endameba histolytica* are the most resistant. Two parallel recommendations for residual chlorine should, therefore, be made; the lower one sufficient for bactericidal purposes, and the higher sufficient for cysticidal purposes. The former should be routinely used for all water supplies where waterborne bacteria only are likely to be present. The latter should be instituted wherever epidemiological evidence indicates endemicity of nonbacterial waterborne diseases such as amebiasis and infectious hepatitis. Existing information suggests that cysticidal residuals are also virucidal (*1–3*).

2. Because of the familiar rapidity of disinfection by hypochlorous acid and hypochlorite ion (free available chlorine) as compared with the slower rate of kill of the combined available chlorine, a distinction must be made between the required concentrations of free chlorine and the combined available chlorine. This distinction is coupled with the strong recommendation that chlorination to a free residual be practiced as widely as possible in military water supplies. It is recognized that the service manuals now call for quantitative differentiation between free and combined chlorine by means of the orthotolidine-arsenite (OTA) de-

termination, following *Standard Methods* (*4*) procedure. Also, a kit has been developed for the armed services that will contain all the reagents, indicators and comparators for the OTA and pH determination, and the minimum concentration shown on the low-range comparator disc (color disc *C*) in the kit is 0.1 ppm and the maximum concentration appearing on the high-range disc (color disc *D*) is 250 ppm.

3. Bactericidal and cysticidal levels of both chlorine and combined chlorine must be specified for two temperature ranges: the normal minimum temperature range (2°–5°C), and the commonly-encountered maximum temperature range (22°–25°C).

4. Residuals for each of the above conditions should be stated for a contact period corresponding to that likely to be attained in field practice, and that this period should be 30 min.

Source of Data

Of all the published data relating to chlorine disinfection, a relatively small fraction is sufficiently explicit to be fitted into the framework of the foregoing conditions. The bactericidal data used in the preparation of Fig. 1 are taken from those obtained by Butterfield and his associates (*5–7*), and the cysticidal data in Fig. 1, 2 and 3, are from Fair and Chang, and their associates (*8–11*).

Several points should be noted about the Butterfield data. First, these data are expressed in terms of the percentage of organisms surviving, as detected by plate counts of 1-ml and 0.1-ml portions. Zero per cent surviving, therefore, signifies a bacterial population of less than 1 organism per 10 ml. In order for a water to meet the mean density criterion of the USPHS drinking water standards (1 organism per 100 ml), residuals slightly higher than those determined by Butterfield would be required. A compensating allowance in the specified residual was made in the following manner. Throughout Butterfield's series, free or combined chlorine residuals were determined at 0, 60, and 120 min regardless of the frequency of sampling for bacteriological determination. Since chlorine demand–free water was employed as the suspending medium, the chlorine concentration rarely showed any decline during the 120-min contact period. Nevertheless, the 30-min residuals specified in these recommendations were taken to be the initial concentration (0 min) shown in Butterfield's data. In water treatment practice, a considerable decrease in chlorine concentration over a 30-min contact period will be experienced, depending upon the chlorine demand of the supply. To obtain a specified residual at the end of a 30-min contact period, the initial chlorine concentration must be considerably higher than the stated value. This will mean, in effect, that the average chlorine concentration over the interval will be somewhat larger than that found to be bactericidal in the Butterfield series.

Furthermore, where Butterfield reported no data for a 30-min contact period, the concentration that proved bactericidal in 20 min was plotted instead; this tends to be conservative. An extensive program of calculating the desired 30-min residuals from the observed 20-min residuals was undertaken, the correction being based on the time-concentration relationship:

$$C^n t = \text{constant}$$

Published values of the concentration coefficient, *n*, were found to be broadly correct but not precise enough for a

designated organism at a stated pH, to warrant their use. (Very roughly, the 30-min residual will be about $\frac{2}{3}$ of of the 20-min residual.) Rather, the more conservative 20-min residual was used instead, even in combination with available 30-min residuals. Envelope

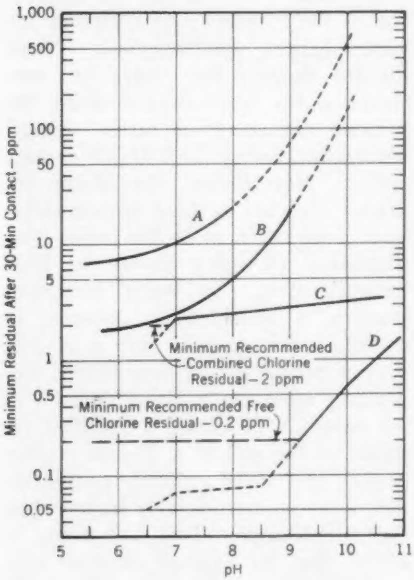

Fig. 1. Minimum Chlorine Residuals for Cysticidal and Bactericidal Doses

Data apply to naturally clear or filtered waters. Line A *shows the curve for cysticidal free chlorine at a range of 2°–5°C; Line* B, *cysticidal free chlorine at 22°–25°; Line* C, *bactericidal combined chlorine (0°–25°C); and Line* D, *bactericidal free chlorine (0°–25°C). Dashed extensions of Lines* A *and* B *represent residual levels at which use without dechlorination is not recommended.*

curves embracing these mixed values, therefore, contain considerable, though not excessive, margins of safety.

Cysticidal residuals determined by Fair and Chang and their associates were furnished to the subcommittee by Chang, together with the relative disinfection rate Q_{10}, and the concentration coefficient, n. Cysticidal combined chlorine residuals have not been firmly established and further studies are required as a basis for a definitive statement. It is anticipated that the cysticidal residuals for relatively short contact periods will be so large as to be of little practical interest.

Figure 1 shows a single line for bactericidal free chlorine residuals for the temperature range 0°–25°C. The same is true for bactericidal combined chlorine residuals. Close comparison of the bactericidal data indicated that the free chlorine residual in each pH bracket in the low temperature range is insignificantly higher than the corresponding values in the normal temperature range. The same feature was observed for combined chlorine residual and, hence, it appeared that a separate line for each temperature range was a dubious distinction. For that reason, the envelope curve was drawn to cover the data for both temperature ranges.

Also shown on Fig. 1 are curves for cysticidal, residual free chlorine for the low and normal temperature ranges. Since these indicate the need for 30-min residuals of more than 50 ppm above pH 8.7 and 9.5 respectively, the subcommittee decided that supplementary charts (Figs. 2 and 3) were needed to indicate the length of contact time required for cysticidal kill with a stated residual at a stated pH. The points on each of these curves were determined by extrapolations with the parameters Q_{10} and n from laboratory time-concentration data. The validity of such extrapolation was checked from several sets of time-temperature

data and agreement was found to be quite good below pH 8.

Margin of Safety

In the foregoing section of the report, it was noted that the use of envelope curves, embracing experimental

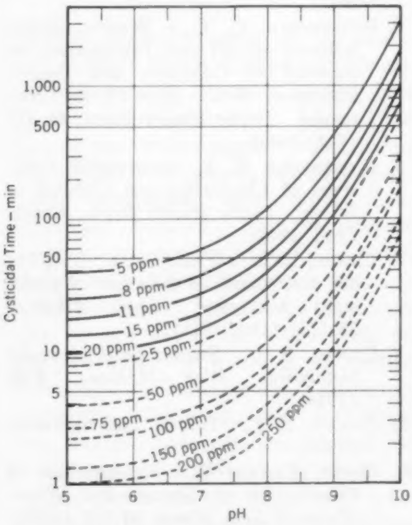

Fig. 2. Minimum Contact Time for Free-Chlorine Destruction of *Endameba hystolytica* at 2°–5°C

Data apply to naturally clear or filtered waters. Dashed lines represent residual levels at which use without adequate dechlorination is not recommended.

data of this type, includes some margin of safety. The extent of this margin is indeterminate, but is not intended to be great enough for all situations. Water having temperatures intermediate between the selected ranges, water possessing significant amounts of organic material, or water having high bacterial or cyst density will all require either higher 30-min residuals than those delineated on the chart or contact periods longer than 30 min. Furthermore, future experimental studies will unquestionably define portions of this chart with greater clarity.

It cannot be overemphasized that the only true guide to proper chlorination is the bacteriological quality of the fin-

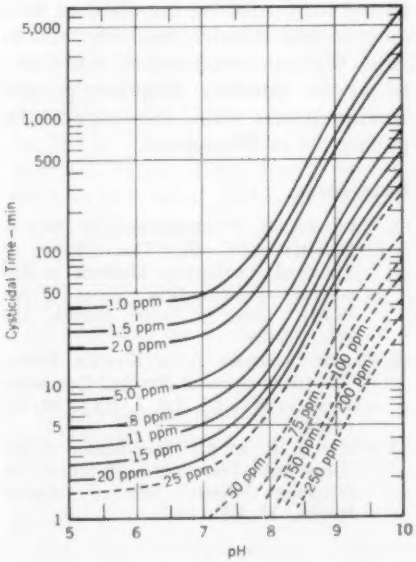

Fig. 3. Minimum Contact Time for Free-Chlorine Destruction of *Endameba hystolytica* at 22°–25°C

Data apply to naturally clear or filtered waters. Dashed lines represent residual levels at which use without adequate dechlorination is not recommended.

ished product. The adoption and maintenance of minimum chlorine residuals should not minimize and can never replace bacteriological analysis as the true measure of potability.

Acknowledgment

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New Chemicals Used in Treatment at Gary

Leo Louis

A paper presented on Feb. 10, 1955, at the Indiana Section Meeting, Indianapolis, Ind., by Leo Louis, Vice Pres. & Gen. Mgr., Gary-Hobart Water Corp., Gary, Ind.

THE filtration plant of the Gary-Hobart Water Corporation is one of the newest in the state, having been placed in operation in May 1954. Gary's raw water supply, which comes from Lake Michigan is relatively good when compared with other Lake Michigan supplies. For the first 46 years of its history, the Gary water supply was chlorinated but not coagulated, settled or filtered. There were thus no set habits to follow with regard to types or methods of feeding chemicals. Consequently, designing engineers, Alvord, Burdick, and Howson, and management decided that the latest and most efficient methods of feeding chemicals should be used. Influencing the decision was the fact that there was no railroad siding at the filtration plant and all chemicals would have to be trucked to the site.

No new methods have been used in chlorination. Ton containers are unloaded from railroad cars at the distribution shop and hauled by a company truck to the filtration plant.

Liquid Alum

Coagulation is ordinarily very simple because of the good quality of Lake Michigan water. Dosages of aluminum sulfate are thus relatively low. In 1955, the alum dosage averaged 110 lb per million gallons, and the maximum dosage was only 150 lb per million gallons. The coagulant, however, and the methods of feeding are somewhat new. Gary was one of the first municipal water plants to use liquid alum purchased directly from the manufacturer. Other plants, such as the one in Columbus, Ohio, have manufactured liquid alum themselves and fed it in that form. Industries, such as paper mills, have used liquid alum for some time. Since May 1954, when Gary started using liquid alum, the Chicago South District Filtration Plant (*1*) (*2*), and the Milwaukee filtration plant (*2*) began to feed alum in this form.

Liquid alum is approximately 49 per cent (36°Be) water solution of aluminum sulfate containing approximately 5.2–5.4 lb of dry material per gallon.

The Gary-Hobart Water Corporation has contracted to purchase liquid alum from two companies. The contract price is based on net tonnage on a dry basis of 17 per cent alum, and the suppliers' calculations are checked by laboratory analysis. The plant of one of the producers is in Joliet, Ill., approximately 50 miles from Gary, while the other is in Kalamazoo, Mich., approximately 100 miles from Gary. Both contracts specify a present price of $33 per ton of dry alum, fob manufacturer's plant. One of the companies uses its own tank truck for hauling, and the other contracts with a trucking company. Both companies afford excellent service, delivering within 48 hr of a telephone order. There is little

to choose between their products. In contracting with two producers, the company insures continuity of supply, although facilities for storing and feeding granular alum are present. The trucks used for hauling are usually equipped with 4,000-gal rubber-lined tanks, and, ordinarily, 3,500 gal are ordered at a time.

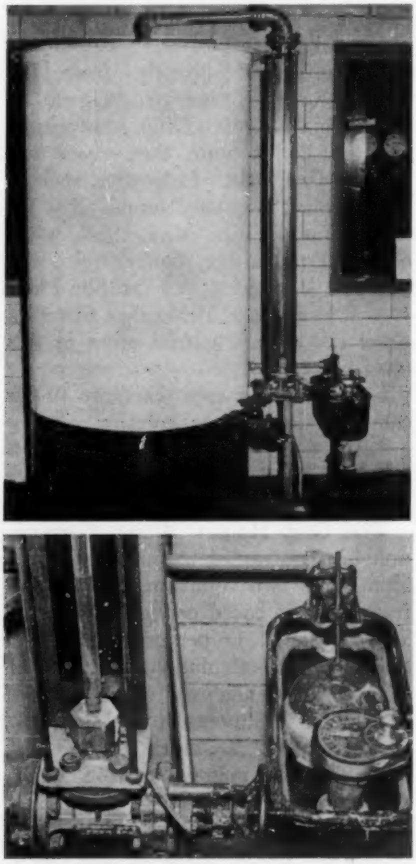


Fig. 1. Day Tank Used for Temporary Storage of Alum

Liquid alum is pumped into the steel, lead-lined day tank shown in the top section. The lower section shows the sight glass and orifice box controlling the dosage.

The tank trucks back up to the rear door of the chemical building and discharge by gravity through a rubber hose into a 6,000-gal lead-lined concrete tank (8 lb lead per square foot) in the basement of the building. The wooden top of this tank is slightly higher than the ground floor of the building. The tank truck can usually be unloaded in 30 min, and the truck driver takes care of the entire operation, so that no plant labor needs be charged to the job.

Alum is pumped from the storage tank ($8\frac{1}{2} \times 8\frac{1}{2} \times 11$ ft) by means of a centrifugal pump powered by a ½-hp motor capable of pumping 15 gpm. The solution is pumped, as needed, into a lead-lined steel day tank 3 ft in diameter and 5 ft high, holding approximately 250 gal (Fig. 1). A graduated, glass, liquid level tube on the side of the day tank records the height of the liquid in the tank, and affords a means of observing and controlling the dosage (Fig. 1). The alum feeds by gravity into an orifice box which has a float control for constant head adjustment. The orifice box discharges through a funnel connection into a 2½-in. lead-lined steel pipe running to the raw water suction well. It is planned to install a second plastic pipeline soon to offset infrequent outages when the steel line must be cleaned because of crystallization and stoppages.

The virtues of this installation lie in its simplicity and small maintenance requirements. The relatively small storage tank inside the building eliminates crystallization of the alum, sometimes a problem when storage time and temperature are not as ideally controlled. It is felt that there is not quite enough storage at the present time, and

consequently, the installation of a second, smaller tank to provide another day's storage is planned this year. Based on a usage of 110 lb alum per million gallons, average daily demand is approximately 400 gal, and maximum demand about 900 gal. Thus, a tank truck must be ordered every 4–8 days.

In the almost 2 years of operation, little trouble with equipment has been encountered, although a leak in the lead lining of the storage tank will soon require attention. There have been no troubles with the pump, day tank, or orifice box, but there are infrequent stoppages in the pipe leading to the suction well. Advantages of liquid alum over granular dry alum are: [1] less cost—$33 a ton against $37 a ton for a 10-ton truck load of 100-lb bags; [2] no handling labor—an estimated 24 man hours to unload a 10-ton load of bagged alum and at least 3 hr a day to fill a feeder hopper, against no labor charged to unloading or charging the day tank; and [3] lower maintenance costs—use of a simple feeding mechanism compared to the gravimetric loss-in-weight type dry feeders. A supply of granular alum in bags is maintained, and a dry feeder is available for use in emergencies.

The first cost of storage tank, pump, and day tank was approximately $3,200. Similar cost of a dry feeder, equipped with a dust collector is $4,000. The disadvantage of liquid alum is the cost of hauling the material long distances. For this reason, it is not economical to consider its use if a producing plant is not located in the immediate area of the filtration plant.

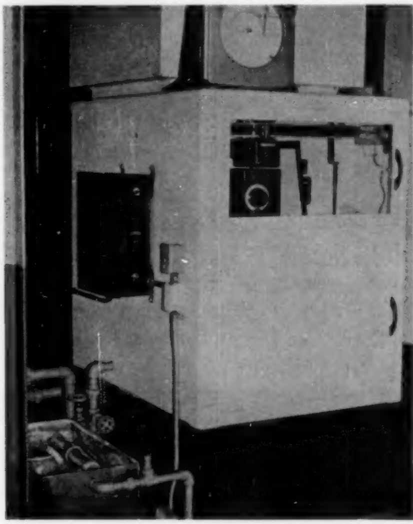
Pickling Liquor

The water company has equipment for the storage and feeding of liquid coagulant, and is located near several large steel mills which waste many gallons of spent pickling liquor every day. The company has thus shown interest in the use of this pickling liquor as a coagulant. J. S. Gettrust has described the utilization of waste pickling acid as a coagulant at the Akron, Ohio, filtration plant (*3*). The sheet and tin mill of a large steel manufacturer is located within 2 miles of the company, and it was discovered that the mill poured thousands of gallons of the liquor every day into a lagoon. Liquor samples were collected and analyzed in the water works laboratory. This waste liquor contained approximately 3 lb per gallon of ferrous sulfate ($FeSO_4 \cdot 7H_2O$) or 1.6 lb $FeSO_4$ per gallon.

According to the Akron experience and jar tests in the company laboratory, chlorine must be mixed with the ferrous sulfate to form ferric sulfate and ferric chloride (chlorinated copperas) to give the best results as a coagulant. Jar tests indicated that fairly good coagulation could be obtained by mixing the pickling liquor, chlorine and raw water all at one time, but that the best procedure is to allow a few minutes detention time for the chlorine and ferrous sulfate to combine, then to add this compound to the raw water in the mixing chamber. The jar tests indicated that a dosage of 33 gal pickling liquor per million gallons or 100 lb $FeSO_4 \cdot 7H_2O$ per million gallons produced a good floc that settled satisfactorily. Comparative tests indicated that 120 lb of alum gave practically the same results. Theoretically, 1 lb of chlorine will oxidize 7.8 lb of iron sulfate. This means a dosage of approximately 13 lb of chlorine per million gallons over and above the average 20–25 lb per million gallons ordinary chlorine demand of the water. Theoretically,

and by jar tests, it appears that approximately 69 lb per million gallons of lime must be fed to restore the pH after the acid liquor is added to the raw water. Based on a chlorine cost of 5 cents per pound, the cost of extra chlorine for a 100-lb per million gallon dosage of ferrous sulfate would be 65 cents per million gallons, and lime at 1 cent per pound would cost 60 cents per million gallons.

The primary reason the use of waste pickling liquor on a plant basis has not been tried as yet, has been the inability to find someone to haul it to the plant. Special fittings and valves had to be installed at the steel companies' waste lines so the liquor could be pumped into a truck, but without a definite commitment from a trucker, misgivings as to the expenses were expressed. The decision to purchase a tank truck was suspended until the results of the plant tests would be known. The trucking company hauling concentrated sulfuric acid to the steel mill uses unlined steel tanks; the spent liquor could not be hauled in the same tanks because of the corrosion factor of the diluted acid, as well as the possibility of contaminating the concentrated acid. No trucker in the area had a rubber-lined or stainless steel tank that would do the job.



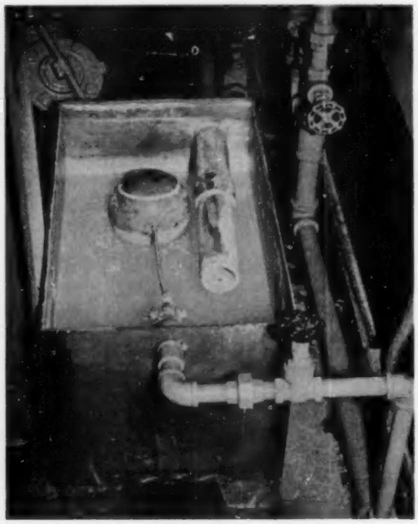


Fig. 2. Loss-in-Weight Gravimetric Dry Feeder and Solution Box

Bentonite clay is fed into the dry feeder shown on the left. After clay has been measured, it is mixed with water in solution box shown on the right.

At $10 per truck load of 880 gal, the hauling cost per million gallons of water treated would be approximately 38 cents. An estimate of 25 cents was given by a trucking company which had no tank truck available. Thus the total cost of pickling liquor treatment, assuming free liquor, would be 60 cents plus 65 cents plus 25–38 cents, or $1.50–$1.63 per million gallons of

water treated. Alum coagulation based on the same 100-lb per million gallons dosage costs $1.80 per million gallons. Further investigation appears worthwhile. There may have to be some changes in the feeding equipment, such as the addition of a reaction pipeline to transport the chlorine and sulfate combination into the raw water, but no major costs should be involved.

Bentonite Clay

As a part of coagulation, a problem arises in Gary during the summer months when algae counts are high in the clear raw water, and the algae become difficult to settle before filtration. The dead algae cells tend to clog the filters, and greatly reduce runs. This condition becomes most serious at a water temperature of approximately 60°F in the early summer and in the fall. In 1954, during the first summer's operation of the filtration plant, filter runs were reduced to 4 hr or less, and ordinary coagulation aids, such as lime, did not seem to help the situation. The turbidity of the raw water was extremely low, and good floc formation was difficult. Algae identification pointed to *Asterionella, Fragillaria,* and *Tabellaria* as the culprits involved.

The plant chemist at that time, Richard Kinser, made inquiries of other filtration plants using Lake Michigan water and found that many had the same condition. He found that Wilmette, Ill., had been experimenting both on a laboratory and a plant basis with bentonite clay and had considerable success with it in weighting the floc and assisting in settling. Four tons of the material was borrowed from Wilmette and experiments were begun. On the basis of those experiments, the company, together with the Michigan City water department, bought a carload of the bagged clay, sharing it equally. The results were good enough in 1954 to warrant the purchase of another carload in 1955. The bentonite clay, shipped in 100-lb multiwall paper bags, was stored with other bagged chemicals. The clay was fed through a loss-in-weight gravimetric dry feeder ordinarily used for lime (Fig. 2); the measured clay was then mixed with water in a stainless steel solution box (Fig. 2) and pumped as a suspension to the raw water suction well. Little trouble has been met in feeding the material.

The use of bentonite as a coagulant aid in water treatment embraces its value, not only as an artificial turbidity producing material, but also as an adsorptive material with negative charges which attract the floc particles in the water and, by adsorption, form larger heavier particles which will settle effectively.

Bentonite clay is produced in two forms: as a powder and as a pellet.* The powder is light gray-tan in color which, when placed in water, swells to three times its dry volume. The pellet is cream colored and swells ten times its dry volume. Greater swellings bentonites are used primarily in foundry molding processes, for drilling through mud in oil fields, and as a detergent in commercial laundries.

The pellet is more efficient in increasing turbidity, and in picking up and holding bodies which may be causing short filter runs, but the high swelling ability also causes it to be somewhat difficult to handle. Sheboygan, Wis., and Wilmette and Winnetka,

* Information on this material was furnished by American Colloid Co., New York, N.Y., which uses the trade names Panther Creek for the powder, and Volclay KWK for the pellet.

Ill., have all tried both types of clay and of the three, only Winnetka prefers the pellets. In Gary, no tests with pellets were made; only the powder has been used.

The Gary experience with bentonite in 1954 and 1955 demonstrated that the use of the material resulted in lengthened filter runs, although it is possible that other factors could have contributed to the change in filter performance.

In the latter part of June 1954, the length of filter runs dropped from a minimum of 18 hr on June 14 to 4 hr from June 16 to 19. On June 18, nineteen filter washes were made. Some of these only lasted 1 min instead of the usual 4 min, but in addition, the filters had to be "bumped" frequently between washes. The condition was better on June 20, but became worse again on the following day with 2 hr runs being recorded on June 25. On that day, 21 filter washes were made with additional filter "bumps." Average percentage of wash water is less than 2.5 per cent of the total water pumped through the plant, but during this period, it averaged 4–5 per cent. Pumpage and filter rates were higher than normal during this period, and on June 25, the maximum hourly total filter rate was 56 mgd. Raw water turbidities were less than 10 ppm and algae counts were apparently high; unfortunately, no record of this data was kept. The total pumpage on June 25 reached a new record day of over 38 mil gal; and filter rates were over 3 gpm per square foot. Continued "bumping" of the filter and short washes were of no help. Consequently, 8,000 lb of bentonite were borrowed from Wilmette.

On June 26, clay was fed at a rate of 32 lb per million gallons; filter runs averaged 10–12 hr. On June 27, filter runs increased again with the same feed rate, and on June 28, the rate was increased to 40 lb per million gallons. The 40-lb rate has since been used as the optimum feed. From June 27 to July 6, the filter runs gradually increased to an average of 50–60 hr, except on June 29, when sixteen filter washes were recorded, possibly because of a very high total filter rate on that day. On July 7, clay treatment was discontinued as the supply ran short. Before treatment was resumed, runs decreased to 3 hr. Within 24 hr of feeding bentonite, runs climbed back to 10 hr. Normal levels were maintained with the exception of some peak periods when filter rates were quite often as high as 3 gpm per square foot.

In 1955, the experiment was repeated with about the same results as in the previous year. On June 21, for example, using no clay, 4 per cent of total pumpage was wash water; after two days of feeding clay at a 40-lb per million gallon rate, the wash water percentage dropped to 1.3. On July 5, the wash water use was over 5 per cent; after clay feed was again started, wash water use dropped to less than 2 per cent.

It is difficult to state conclusively that the bentonite was altogether responsible for increasing filter runs during these periods. Graphs indicate that filter rates fluctuated somewhat parallel to the filter wash water usage and filter runs, but generally, the use of clay tended to keep wash water use at a lower level, regardless of the filter rates. Lack of data on algae counts is regretable as it might have served to complete the story.

Conclusions were that bentonite afforded more efficient operation resulting from better coagulation, and of-

fered definite cost savings in demanding less wash water. Bentonite in powder form costs approximately $1.55 per 100 lb fob Gary in a 30-ton carload lot. Based on a 40-lb per million gallon feed rate, the additional cost of clay is approximately 62 cents per million gallon. Maximum pumpage on one day last year was 42 mil gal. Assuming a reduction in the number of washes from 21 to 8, as occurred in actual experience, thirteen washes would have been saved at 130,000 gal each, or a total of 1,690,000 gal of water. Some of the 21 washes, however, lasted 1 instead of 4 min, decreasing the wash water savings to about 1,000,000 gal. Average treatment and pumping cost at the main plant was approximately $30 per million gallons in 1955, so the savings on wash water for a day would be $30. The cost of bentonite on that 42-mil gal day was $26.04, or a little less than the cost of the water.

It is difficult to determine actual savings from plant records. Day to day pumpage fluctuations, different filter rates during the night and day hours and the habits of filter operators tend to limit any final judgment.

Liquid Ammonia

Gary is not the only filtration plant to use bulk delivery of anhydrous ammonia. Two suppliers deliver it in tank trucks equipped with several pressure vessels. The trucker connects his pressure vessels to adapters in the outside wall of the chemical building which, in turn, are connected to a filling line and a vent line leading to a steel storage tank. The liquid ammonia is then pumped through the filling line to the storage tank while the vent line returns displaced gas

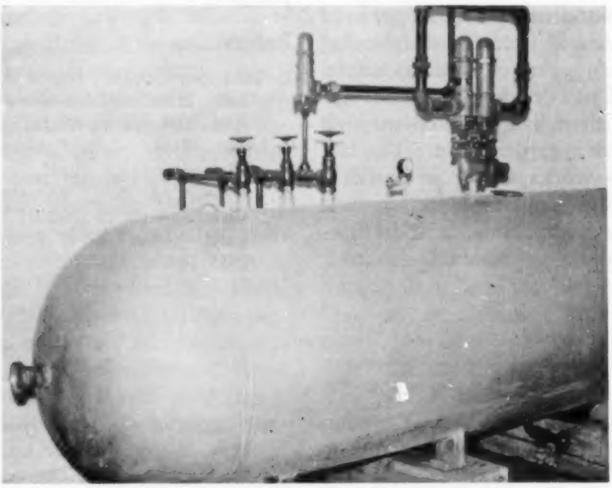


Fig. 3. Liquid Ammonia Storage Tank

The tank, located on the second floor of the building, can accommodate over 4,000 lb of liquid ammonia.

from the storage tank to the pressure vessels. The storage tank (16-ft long and 3½ ft in diameter), shown in Fig. 3, is about three-quarters full after the usual 3,000–4,000-lb load has been delivered. A smaller day tank, located in the floor below, is mounted on platform scales. It is filled by gravity flow when weight drops to the 200-lb level.

Disinfection

The last relatively new chemical used in Gary is a quaternary ammonium compound containing 10 per cent active agent, and used for disinfecting pipelines. A gallon of water is mixed with ½ lb of powder, and the mains are swabbed with a long-handled mop or sprayed with a garden hose. The latter method works better in freezing weather. The solution is better than hypochlorite compounds as it is noncorrosive and has residual qualities. No attempts have been made to disinfect anything but pipe surfaces.

Acknowledgment

The author gratefully acknowledges the assistance of various members of the operating staff of the Gary-Hobart Water Corporation, including Harry Harman, superintendent of operations; Richard Kinser, former plant chemist; H. L. Plowman, Jr., present plant chemist; and Frank Fellows, pumping station supervisor.

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Calcium Carbonate Stabilization of Lime-softened Water

Herbert O. Hartung

A paper presented on May 7, 1956, at the Diamond Jubilee Conference, St. Louis, Mo., by Herbert O. Hartung, Production Supt., St. Louis County Water Co., St. Louis, Mo.

In a lime-softening water treatment plant, the advantages of precipitating the supersaturated lime-softening reaction products in the treatment basins prior to filtration are readily apparent. These supersaturated salts, primarily calcium carbonate, characterize the softened water as being unstable because of afterprecipitation on filter sand and pipelines. Their removal in the treatment plant would result in a softer effluent, usually lower filter maintenance costs, increased softening per unit of lime added, and elimination of recarbonation, except, perhaps, when high-residual magnesium at the higher pH values would cause domestic hot water–heater plugging.

Recarbonation for stabilizing lime-softened water, as customarily applied in the water treatment plant, has the obvious disadvantage of arresting the softening process prior to complete precipitation of the lime reaction products. Afterprecipitation is prevented by lowering the pH of the water until the supersaturated salts become normally soluble. The amount of softening obtained per unit of applied lime then depends on the stage in the softening processing at which recarbonation is applied and the original amount of supersaturated salts, along with other factors. It is not uncommon in the water softening plant to recarbonate 20–30 ppm of supersaturated hardness which might have been precipitated if facilities for causing such precipitation were available.

The addition of a polyphosphate salt to sequester supersaturated calcium carbonate is similar to recarbonation, in that the water is stabilized by holding the unstable hardness in solution. Again, the water treatment plant effluent would be softer and the softening efficiency increased if supersaturated hardness would be precipitated rather than held in solution by sequestering.

In a few water softening plants, the water, after lime-stabilizing, is stabilized by precipitating the supersaturated hardness on the filter beds. After the sand grains of the filter bed are coated with calcium carbonate, such softening is often appreciable and the distribution system is therefore protected against afterprecipitation. The disadvantage of the filter water stabilization method is that the filter bed sometimes becomes cemented, causing ineffective filter washing and more filter bed maintenance. The sand grains of the filter also grow in size until filter sand replacement becomes necessary. At the St. Louis County Water Company, filter sand with an original effective size of 0.44 mm was resieved annually and reused. After about 10 years of such resieving, the effective size was over 1.2 mm. Average hardness precipitation on the filters was about 10 ppm. The cost of this sand replacement and the required

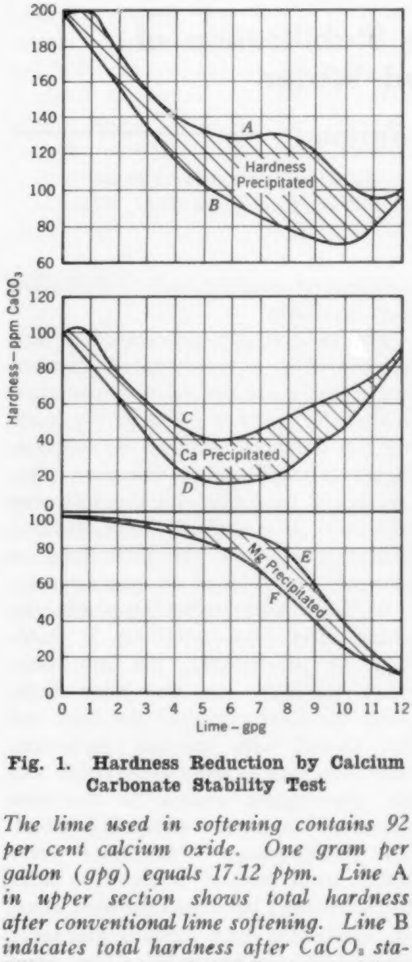

Fig. 1. Hardness Reduction by Calcium Carbonate Stability Test

The lime used in softening contains 92 per cent calcium oxide. One gram per gallon (gpg) equals 17.12 ppm. Line A *in upper section shows total hardness after conventional lime softening. Line* B *indicates total hardness after $CaCO_3$ stability test. Lines* C *and* D *show calcium hardness after softening and $CaCO_3$ stability test. Lines* E *and* F *show magnesium hardness after softening and $CaCO_3$ test.*

filter maintenance, however, was computed to be less than recarbonation costs, and, in addition, the water consumers enjoyed a softer water.

Long storage of lime-softened water, as a means of causing precipitation of supersaturated hardness, is not dependable. At the St. Louis County Water Company, for example, after softening and prior to filtration, lime-softened water has been stored in treatment basins for 24–48 hr or longer. During a 3-year period, such lime-softened water, having 8–41 ppm of supersaturated hardness (an average of 24 ppm), lost only an average of 2 ppm of its hardness during such storage.

A lime-softened water containing 29 ppm of supersaturated hardness was stored in a completely filled and stoppered 5-gal carboy for 2 months in the laboratory. At the end of the storage period, only 15 ppm of the hardness had precipitated. On the other hand, supersaturated hardness from this water could be precipitated easily by adding and mixing the water with appreciable calcium carbonate surface.

A stable lime-softened water can be produced in the laboratory by means of the well-known calcium carbonate stability test. A quantity of alkali-free precipitated calcium carbonate is added and mixed with the unstable water. The calcium carbonate causes the precipitation of the supersaturated hardness upon its surface. A determination of the water alkalinity before and after contact with the calcium carbonate measures the quantity of supersaturated hardness.

The possibility of producing a stable lime-softened water in the water treatment plant by the calcium carbonate stability test method has been under study periodically at the St. Louis County Water Company since about 1940. Following a series of laboratory studies, a pilot plant was constructed and operated in 1941–42, treating Meramec River water to determine the feasibility of utilizing the suspended

solids contact basin. Then, in 1955, a 6-mgd experimental suspended-solids type of stabilizer basin was placed in operation at the new North County Plant. In 1956, another suspended-solids contact softener was placed under construction at the South County Plant, to be used for both softening and stabilization.

Initial Laboratory Studies

The amount of supersaturated or additional hardness which can be precipitated from the conventional lime-softened water by the calcium carbonate stability test method has been studied in the laboratory. Results of a typical study are given in Fig. 1. Meramec River water was softened with various amounts of lime by jar test methods at a controlled water temperature, and the hardness was determined. The softened water was then contacted with an appreciable quantity of precipitated calcium carbonate by rolling in completely filled bottles for 60 min or more, and the hardness again determined.

These studies have quite clearly shown that often 30 ppm or more of additional hardness reduction than is being obtained in conventional softening plant practice, is sometimes possible. Another interesting result is that both calcium and magnesium are precipitated during the calcium carbonate contacting period. The magnesium reduction takes on added significance because of hot water–heater clogging problems sometimes caused by magnesium.

The study also brought out the fact that an acceptable soft water can be produced by the calcium carbonate contacting procedure, even when alkalinity of lime-softened water is less than caustic prior to contacting. During the study whose results are shown in Fig. 1, a 100-ppm hardness water was produced when the lime dose was less than the alkalinity equivalent of the raw water. It is for this reason that recarbonation or acid treatment of the water might be eliminated when calcium carbonate contacting processing is added to conventional lime softening.

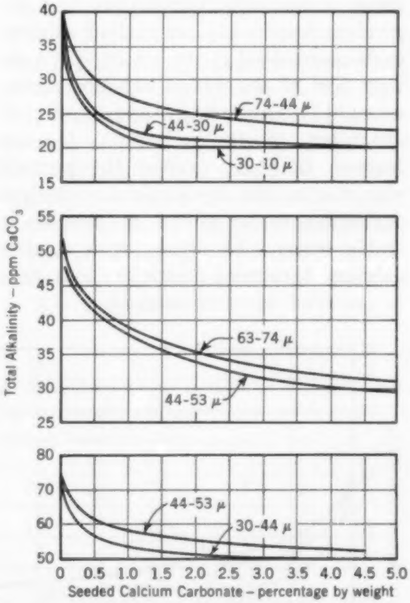

Fig. 2. Effects of Calcium Carbonate Particle Size and Concentration

Mixing time in all three studies was 30 min. In the study shown at the top, water temperature was 82°F and pH 9.9. In the center study, temperature was 50°F and pH 10.0. In the bottom study, temperature was 65°F and pH 9.7.

Further laboratory studies have shown that, within limits, the rate and amount of hardness precipitation obtained during calcium carbonate contacting with a given lime-softened

water at constant temperature, are dependent upon: [1] amount of calcium carbonate added to the water; [2] particle size of the added calcium carbonate; [3] contacting time; and [4] character of the mixing. It was learned that the smaller the particle size, the smaller the amount of calcium carbonate to be added to produce a stable water. Similarly, with smaller calcium carbonate particles, less time is required for stabilization.

Longer mixing times and higher concentrations were required to bring the water to stability when 100-mesh material was used. Particle size over 100 mesh created considerable difficulty by keeping the calcium carbonate in suspension in the jar-test stirring apparatus. In these studies, the bottles, after being filled and stoppered, were placed in rolling machines.

As might be expected, conditions required to produce stability varied

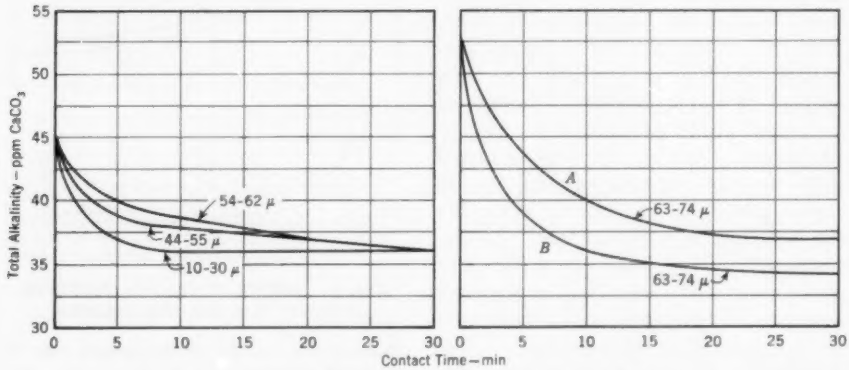

Fig. 3. Effects of Varying Time on Alkalinity Reduction

The section on the left shows the alkalinity reduction when the lime-softened water is contacted by a 2 per cent by weight seeded calcium carbonate concentration for various periods of time. The temperature remained constant at 80°F and the pH at 9.8. In the section on the right, Curves A *and* B *show the reduction when 63–74 μ calcium carbonate was used. In Curve* A, *however, only 2 per cent by weight was added; in Curve* B, *4 per cent.*

Particle Size and Contact Time

Typical studies which show both the effect of particle size and the concentration of the added calcium carbonate required to precipitate supersaturated hardness from lime-softened water, when mixing time and temperature were held constant, are shown in Fig. 2. When the particle size of the added calcium carbonate was less than 30 μ, very small amounts would produce stability in a relatively short time.

somewhat with each water studied. Temperature, pH, the degree of unstableness, character of mixing, and so on, were observed to be influencing factors when determining the amount and particle size of calcium carbonate required to obtain stability. Thus, the results shown in Fig. 2 cannot be applied indiscriminately to all lime-softened waters.

The time required to produce calcium carbonate stability was also an

important subject for laboratory study. The results of typical studies in which the size and concentration of seeded calcium carbonate particles were held constant, and the time of mixing was varied, are illustrated in Fig. 3. These studies indicated that the exact time required to produce a stable water varied.

A stable or near stable water was always obtained when the added calcium carbonate particle was smaller than 200 mesh, the quantity of the added calcium carbonate was in excess of 3 per cent, and the mixing time was 30 min or more. It was apparent in all laboratory studies that, if the seeded calcium carbonate particle could be of flour-like fineness, the quantity required would be small and the stabilization of the water would be fast.

For practical reasons, in water-softening plant practice, the particle size of any added calcium carbonate must be sufficiently large to allow separation between the water and the calcium carbonate in a treatment basin. The calcium carbonate particle must also be sufficiently small to cause hardness reduction in a reasonable time and at a reasonable cost. Because the suspended solids-contact basin seemed to be functionally best suited for contacting lime-softened water with seeded calcium carbonate, an investigation was made to determine the particle size which can be suspended and retained in this type basin.

TABLE 1

Approximate Hydraulic Settling Values of Calcium Carbonate Spheres in Water

Diameter of Particle		Settling Velocity—*ft/hr**					
Mesh	μ	35°F	40°F	50°F	60°F	70°F	80°F
	150	133	148	177	207	236	266
100	147						
150	104						
	100	71	78	94	110	125	141
	80	53	59	71	83	95	107
200	74						
	60	34	38	45	53	60	68
	50	26	28	34	40	45	51
325	44						
	40	19	21	25	29	33	38
	30	11	13	15	18	20	23
	20	5	6	7	8	9	10
	15	3		4		5	6
	10	1.5		2			3

* A rise rate of 2 gpm per square foot is equivalent to 16 ft/hr.

The settling rates of calcium carbonate spheres (2.65 sp gr) calculated from Stokes' law are shown in Table 1. From this tabulation, it was postulated that if a 2-gpm per square foot suspended-solids contact basin is to be seeded with calcium carbonate, the particle size must be larger than about 40 μ (325 mesh equals 44 μ). Particles smaller than about 40 μ would cause a turbid effluent. The maximum size particle which might be held in suspension would depend upon the character of the mechanical mixing.

A preliminary experience indicates that this maximum size is about 100 μ (150 mesh equals 104 μ) or smaller.

Laboratory studies indicated that the stabilization of lime-softened water by seeding with calcium carbonate particles is feasible in full scale plant practice, provided that:

1. The seed calcium carbonate is about 150–325 mesh in size and its concentration in the stabilization basin is about 3–5 per cent by weight
2. The stabilization basin is designed to keep the seeded calcium carbonate in suspension
3. The seed calcium carbonate can be continually reused to reduce costs
4. The contacting time with the seed calcium carbonate is 30 min.

Confirmation of Studies

A 5-gpm pilot stabilizing basin was then installed at St. Louis County Water Company's Central Plant to test these laboratory conclusions. The pilot-stabilizing basin was a solids-contact model having a rate of 2 gpm per square foot. Lime-softened water from a plant purification basin was pumped into the stabilizer. Seed calcium carbonate was added in batches to build the concentration in the center draft tube to 5 per cent by weight. The effluent from the stabilizer was periodically checked for turbidity and hardness reduction.

The pilot plant study confirmed the general laboratory findings. Three important practical aspects and difficulties related to the stabilization processing were also learned:

1. Crushed limestone with particle size limited to 150–325 mesh was not available from any of the 20 available producers. Sieve analyses of numerous other samples of crushed stone were made and studied. The best stone available contained only about 25 per cent usable particle sizes. This discovery added emphasis to the requirement of continuous reuse of the seeded calcium carbonate in order that the processing be economically feasible.
2. The character of mixing in the conventional suspended solids contact basin is not adequate for keeping a 5 per cent seeded calcium carbonate slurry in suspension. The pilot stabilization basin had to be redesigned with additional horsepower to provide adequate mixing.
3. It was learned that it was difficult to prevent some solid deposition in the outer areas of the stabilizer wherever mixing velocities were reduced.

Retained Slurry Uses

Another study approach to this method of stabilization was to utilize previously precipitated and accumulated lime-softening sludge instead of added crushed limestone. This was investigated as a part of a Meramec River pilot plant operation in 1941 and 1942. The pilot plant consisted of three suspended-solids contact basins: one 5-gpm and two 25-gpm basins.* Lime-softening precipitate or slurry, was, at various times, allowed to accumulate in these units beyond that proper for best water-solids separation, in an attempt to increase softening and produce a stable water. The lime required for softening was added either to the raw water entering the suspended solids contact unit, or to the circulating slurry.

* The 5-gpm basin is the Spaulding Precipitator manufactured by The Permutit Co., New York, N.Y. The 25-gpm Accelator is manufactured by Infilco, Inc., Chicago, Ill. The 25-gpm Hydro-Treator is manufactured by Dorr-Oliver Co., Stamford, Conn.

A stable lime-softened water usually could be produced whenever lime softening was in the presence of about 5 per cent by weight or more of previously precipitated and suspended lime-softening slurry. Improved softening was obtained when the slurry concentration was 2 per cent or more.

The increased hardness precipitation obtained in the suspended solids contact basin pilot plant units when softening was in the presence of 2 per cent or more of slurry, and the lime dose was equal to the alkalinity equivalent of the water, as shown in Fig. 4. As much as 30-gpm additional hardness precipitation was obtained under some conditions of operation when softening was in the presence of considerable previously precipitated slurry.

That more softening could be obtained per unit of added lime when the retained slurry concentrations were 2 per cent or above, was also established. Operating periods were compared when the suspended solids contact units did and did not contain slurry. Table 2 groups 166 days of a 25-gpm basin operation according to suspended solids concentration, and indicates that increased softening was obtained with the higher slurry concentrations.

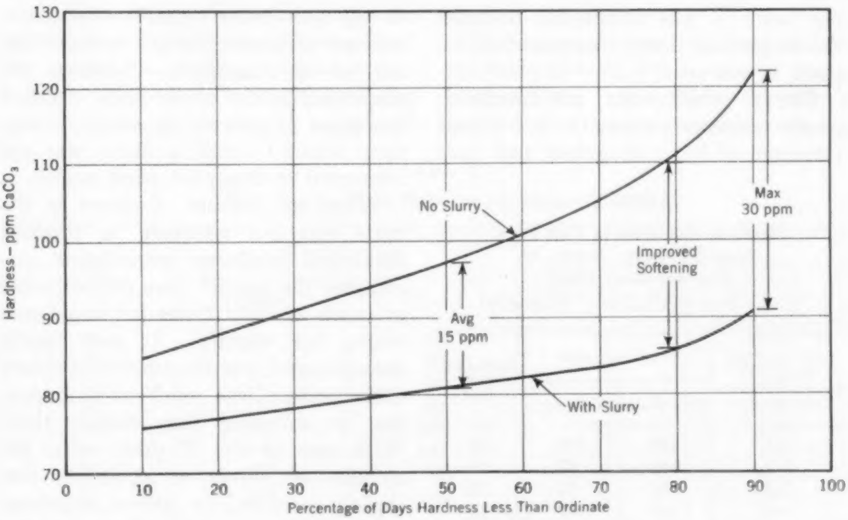

Fig. 4. Effects of Accumulated Softening Slurry

The upper curve represents the alkalinity of Meramec water over a 90-day period when treated by conventional laboratory methods. The lower curve represents alkalinity reduction when the water contains a lime-softening slurry greater than 2 per cent by weight.

An important observation was that when these upflow basins were operating at 2-gpm per square foot rise rates, and the slurry in the unit was 5 per cent or more by weight, the effluent was highly turbid from lime-softening slurry. In other words, it was not possible to obtain a clear effluent and,

at the same time, have a high concentration of slurry in the basin. On the other hand, it was not always possible to build a 5 per cent slurry within the softening basins. Cold water temperature, and a high percentage of magnesium hardness precipitated sometimes prevented such accumulations. Slurry would then boil out with the effluent water. Occasionally, when the rise rate in one of the units was only 5 ft per hour, it was impossible to build the suspended slurry concentration beyond 1¾ per cent.

Slurry which was not predominantly calcium carbonate, but rather consisted of ferric coagulant and river turbidity, was only partially effective in causing stabilization at the concentrations studied. The disadvantage to softening when a coagulant floc was an appreciable percentage of the slurry, was repeatedly demonstrated in pilot plant operation. This observation was confirmed in the laboratory by attempting to stabilize lime-softened water by seeding and mixing the water with sand and a number of other water-insoluble solids. There is less hardness deposition on new filter sand than when the sand is coated with calcium carbonate.

TABLE 2

Hardness Reduction in Pilot Plant Lime-Softening Basin of Meramec River Water

(*Lime Dose Equivalent to Alkalinity*)

Per Cent by Weight of Suspended Solids Concentration	Hardness—*ppm*		Operating Period—*days*
	Raw Water	Effluent	
0–1	160	106	56
1–2	160	87	57
2–3	172	84	28
3–4	172	82	25

During pilot plant operation, it was also observed that the precipitated calcium carbonate particle on some occasions was of such small size that it would be hydraulically swept out of the suspended solids contact basin. A coagulant was then necessary to build a suspended solids slurry. Various factors seemed to influence the size of the precipitated calcium carbonate particle, chief of which was temperature. It was not always possible to obtain a calcium carbonate surface without the aid of a coagulant. Seeding the suspended-solids units with crushed limestone to provide an initial surface upon which to build a slurry was not attempted in this pilot plant study.

When the amount of slurry in the units was not adequate to produce maximum hardness precipitation, increasing the contact time in the basins as much as eight times improved softening but slightly. It was clearly demonstrated that the amount of slurry concentration was much more important to softening than mixing time. With one of the 25-gpm units, the amount of slurry recirculation was slightly increased on several occasions, to the extent allowed by increasing the speed on the mixing-pumping blades, without noticeably improving softening.

The amount of softening slurry required to produce a stable lime-softened water in these pilot plant suspended solids contact units was also dependent upon the kind of river water being softened. It happened many times, for example, that a river water of 125-ppm total alkalinity (total hardness 145 ppm), required considerably more slurry to cause stability than did a raw water of 160-ppm total alkalinity (total hardness 190 ppm). In other words, it was observed that the higher hardness waters encountered

were easier to soften to stability than the softer water.

Experimental Stabilizer Basins

In 1955, a 6-mgd capacity stabilizer basin was constructed in one corner of the final settling basin at the North County Plant of the St. Louis County Water Company, immediately adjacent to a filter. A sketch of this unit is shown in Fig. 5. Water flow is from the final settling basin, through the stabilizer to the filter, and is regulated by a filter rate-of-flow controller.

The stabilizer basin mechanism was specified (but not realized) to recirculate the water in the basin up through the center draft tube and out through the rotating distributing arms at a 120-mgd rate (twenty times the maximum throughput rate). The rise rate at the surface of the basin is calculated to be 2.3 gpm per square foot when the flow-through rate is 6 mgd. The rotating distributing arms are 48-ft in diameter and are powered by a ¾-hp motor. The speed of the distributing arm is ¼ rpm. The rotor blade pump for circulating the slurry is powered by 7.5-hp motor.

The water in the final settling basin is lime softened and coagulated Missouri River water. The turbidity is consistently less than 10 ppm. The hardness which can be precipitated from this water by the calcium carbonate stability test is usually 10–15 ppm.

Calcium carbonate for stabilizing the water is added to the basin through a chemical feeder. Only about 24 per cent of the calcium carbonate is between 150 and 325 mesh (104–44 μ) in size.

Calcium carbonate has been fed to the basin to build a 4–5 per cent slurry concentration. Whenever the slurry reached this concentration, softening results were as expected. Table 3 gives the results of a 1-week period of satisfactory operation.

TABLE 3

North County Plant Stabilizer Operation Results

Date (Mar. 1956)	Hardness—*ppm*		Hardness after Calcium carbonate Stability Test—*ppm*	Percentage of Solids in Draft Tube
	Influent	Effluent		
14	108	86	86	2.5
15	119	90	89	5.0
16	112	97	87	5.0
17	111	98	91	4.0
18	108	100	90	4.0
19	109	100	92	4.0
20	106	98	90	4.0
21	105	96	87	4.0

Operating results from this experimental unit, however, cannot yet be reported as either successful or unsatisfactory. A series of disappointments and problems have been encountered, all of which have not yet been solved.

Initially, the stabilizer basin was square. Calcium carbonate slurry which migrated into the corners of the square basin was out of reach of the rotating distributing arms; it settled and was lost to use. The amount of calcium carbonate feed necessary to re-

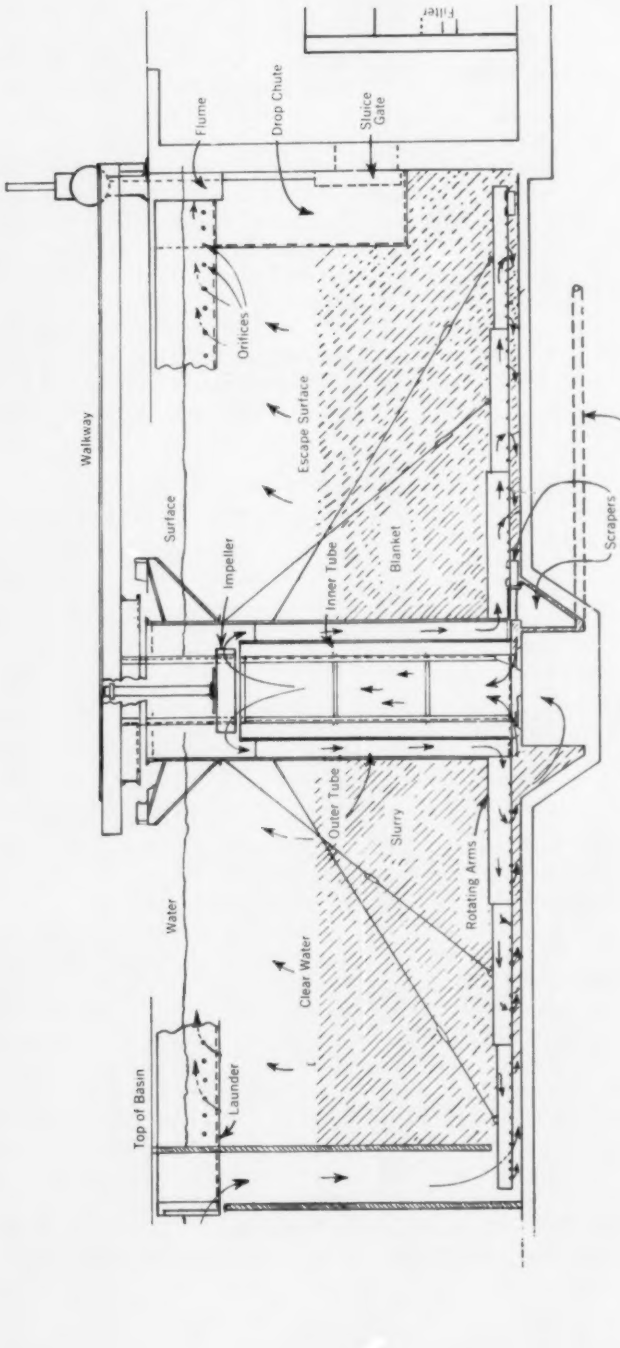

Fig. 5. Stabilizer at the North County Plant

Water in this 6-mgd capacity stabilizer basin enters from the final settling basin, and exits through the center draft tube.

place that lost in the corners was of such quantity that the process was judged as not proper for a square basin. It was then converted to a round basin by the installation of corrugated steel sheeting.

A number of corrections to the basin mechanism have been necessary, and others are contemplated. Changes were made in an attempt to increase circulation of the water, replacing bearings, and so on. The details of these changes are not pertinent to this article except as they might indicate that design of a suspended-solids contact basin for calcium carbonate stabilization cannot be identical to the design used for conventional softening and clarification.

The problem basic in successful stabilizer operation is to keep the calcium carbonate slurry in suspension without causing a turbid effluent. In the basin being studied, a very delicate balance between the character of mixing, the upflow velocity, the slurry particle size and water temperature is necessary. Slurry which does not rise with the effluent is not easily held in suspension. Similarly, fine particles in the added calcium carbonate have kept the applied filter water turbid.

Calcium carbonate slurry has accumulated near or on the bottom of the basins, causing an overload on the distributing-arms drive, while the slurry in the draft tube has remained less than 0.5 per cent. This type of problem clearly indicates that more study must be given to the type of calcium carbonate which is to be used in seeding. The need for a recirculation of slurry at rates equal to that originally specified but not yet obtained, is also indicated.

Study and experimentation is continuing in an effort to make the stabilizer function economically. It has already been clearly established that precipitation of supersaturated hardness is possible in a stabilizer basin, but costs of operation have been too high. Operation will become economical when a properly seeded calcium carbonate slurry can be recirculated and reused for a longer period of time. Some of the stabilizer operating data to date point to a possible operating cost of about $1 per million gallons. Assuming a 6-mgd stabilizer having a 3-mgd average load, the breakdown is shown in Table 4.

TABLE 4

Predicted Cost of Operation

Item	Quantity per Million Gallons	Unit Price	Cost *$/mil gal*
Initial $CaCO_3$ seeding	0.021 ton*	$7/ton	0.15
Power	8.25 hp	1¢/kwhr	0.50
Replacement $CaCO_3$	0.05 ton†	$7/ton	0.35
Total			1.00

* Based on 23 tons per year for 3 mgd (5 per cent by weight in half of basin volume); initial seeding once each year after draining basin for maintenance.

† 100 lb per million gallons.

At the South County Plant of the St. Louis County Water Company, a suspended solids contact basin is under construction as the first of two stages for processing Meramec water in a lime-softening and coagulation plant. It is intended that this first stage treatment will be both for softening and stabilization. The precipitated hardness from lime softening will be retained to form the calcium carbonate slurry necessary for stabilization. Slurry which boils out of the unit will be separated from the water in a subsequent settling zone. As this basin is not yet in operation, discussion will be reserved for future reporting.

Summary

Afterprecipitation from lime-softened water which would cause filter sand and pipeline incrustation, is usually prevented by recarbonation or by sequestering. This article discussed the removal of supersaturated hardness by contacting the softened water with a slurry bed of calcium carbonate. In laboratory and pilot plant operation, this processing was found feasible. However, a number of important problems have been encountered in a 6-mgd prototype installation. Stabilization of the water in the prototype unit has been possible, but costs have been high because of the difficulties of holding the available calcium carbonate particles within the basin or in suspension. Study and experimentation are continuing, but no predictions can yet be made.

Discussion

Vincent J. Calise

Tech. Director, Graver Water Conditioning Co., New York, N.Y.

The preceding article is an informative one because of the rather bold and pioneering nature of the large-scale equipment installation for post-stabilization of lime-treated and settled water by "high-rate" solids-contact basins to reduce hardness further in the close-to-solubility product region. The data presented on stabilization tests and plant performance in this range of solubility product values and the indication of difficulties experienced so far in this work on both pilot and large scale plant results also add to its interest.

The stabilization of cold lime-treated and settled water by contact with large quantities of ground calcium carbonate is well known, and has been referred to in the literature many times.

Conventional cold lime softening, with or without solids contact by recirculation, has a place in the kit of the municipal design engineer wherever conditions of load, operation, climate, and raw water quality dictate such a need over high-rate plants. The practical approach is to have both plant designs available, and to use the most suitable.

Solids-contact units, in which cold water is continuously softened or clarified, were developed from batch-treat processes employed in water treatment more than 100 years ago. Many such batch-treatment processes are employed throughout the world today, and are subject to the same problems experienced many years ago with the transition from batch treatment to continuous treatment. These problems revolve about the fact that the chemical precipitating reactions which take place at cold-water temperatures are completed very slowly, even with large excesses of chemical reagents. Large retention tanks were thus required for treating sizable quantities of water to obtain fairly complete chemical reaction and proper settling of solids. It was also apparent that incomplete chemical reactions and high turbidity were obtained, causing large excesses of chemicals even with agitation and settling periods of 4–6 hr.

The change from batch to continuous treatment was stimulated mainly by the need for smaller and cheaper equipment. Efforts were made to employ well-known chemical and physical

principles in designing continuously operating cold-process chemical precipitation units for treating water. After proper mixing of water and chemicals, for example, it was found necessary to employ low upward settling velocities through relatively great

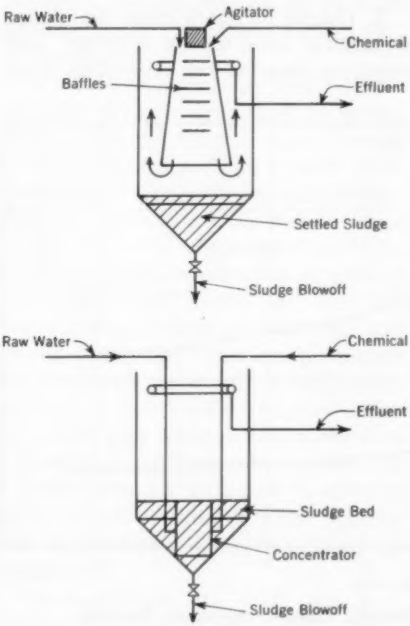

Fig. 6. Early Types of Continuous-Treatment Units

The upper section shows a European design dated 1850–1900 which does not attempt to use the already formed precipitated solids. The lower section shows the Duclerc design (1905) which made use of heavy particles in softening water.

heights in order to settle out precipitated solids. Attempts were also made to increase the density and size of the precipitated particles to obtain quicker and easier settling. Early designs, of the type shown in Fig. 6, made no attempts to employ the already formed precipitated solids to hasten the chemical reaction or to form more settleable precipitates.

Seeding in Chemical Reactions

At the turn of the century, chemists were able to show commercial applications of the principle of contacting reagents and solutions with already formed precipitates in speeding up chemical processes. The advantages found for this practice applied mainly to reactions taking place at colder temperatures.

Water treatment chemists found similar benefits by using this principle in water treatment reactions. It was found, for example, that the addition of already formed solid precipitates presented such a great surface area in the mixture of water and chemicals that the newly formed precipitates formed more quickly, with less excess of chemical reagent. In addition, the precipitates formed on the surfaces of the already formed particles resulted in heavier, more easily settleable particles. The effect of seeding is shown in Fig. 7, where rate of softening is appreciably affected by contact with accumulated precipitates or seed, as well as temperature.

One of the first commercial applications of this principle in water treatment was the Duclerc unit shown in Fig. 6. In this unit, incoming water and chemicals were contacted with a bed of heavy solid precipitates; the unit then allowed the settling of any particles of turbidity not removed by precipitation. This unit was subject to some channeling of water and chemicals and improper mixing, so that it was redesigned some years later.

The early units installed were operated principally for cold-process lime or lime-soda softening applications,

where very heavy and settleable precipitates of calcium carbonate and magnesium hydroide were formed. Later, these same units were applied to clarification of highly turbid or colored water, where coagulants such as alum and iron salts were employed, and where, in many instances, the precipitates formed were lighter and not as easily settled as the calcium and magnesium salts.

The factors which influence the clarity of treated water are:

1. Upward velocity of treated water in the region where separation of solids from the water occurs (also called the upward settling rate, and usually expressed in gallons per minute per square foot)
2. Height of liquid from the sludge separation zone to the collector, and retention time in the separation zone

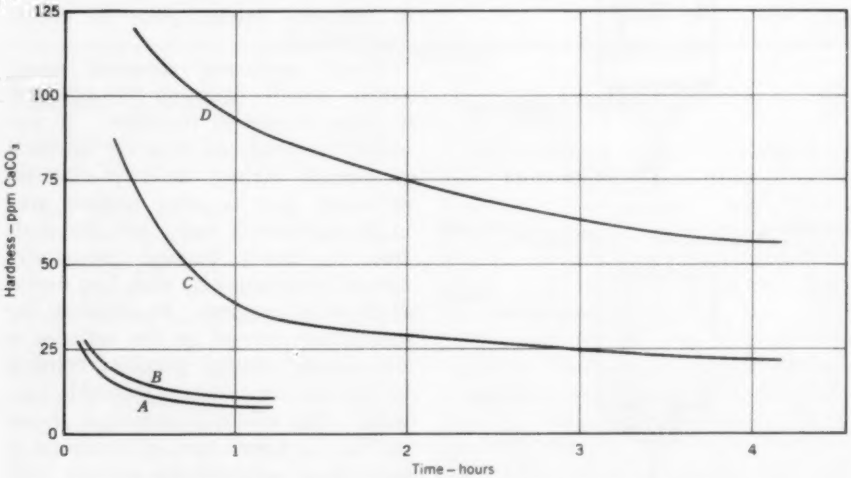

Fig. 7. Effects of Temperature and Contact Time on Speed of Reaction

Curve A—*Temperature 208°F; 230 ppm soda ash added to 200 ppm calcium chloride and 100 ppm accumulated calcium carbonate precipitate. Curve* B—*Temperature 208°F; 230 ppm soda ash added to 200 ppm calcium chloride. Curve* C—*Temperature 60°F; 230 ppm soda ash added to 200 ppm calcium chloride plus 1,000 ppm accumulated calcium carbonate precipitate. Curve* D—*Temperature 60°F; 230 ppm soda ash added to 200 ppm calcium chloride.*

Two variations of hot-process softeners are shown in Fig. 8.

Separation of Precipitated Solids

Once solid precipitates are properly formed by chemical reaction, the treating unit must be designed to effect maximum separation of all coarse and fine particles from the treated liquid.

3. Viscosity of the treated water (this value is mainly a function of the temperature of the water)
4. Density of the treated water
5. Density of the solid particles
6. Size of the solid particles.

In a quiescent medium, the settling velocity of a solid particle in water may be calculated from Stokes' Law as

follows:

$$V = \frac{18.5D^2(S_1 - S_2)}{Z}$$

where V is velocity of fall, in feet per second; D, diameter, in inches of particle; S_1, density of particle, in pounds per cubic foot; S_2, density of fluid, in pounds per cubic foot; and Z, viscosity, in centipoises.

In units of present-day design, however, the solid particles must be settled downwardly in treated water having upward velocity and an upward force component. The cold-process softener, clarifier, and hot-process softener have certain desirable characteristics. The designs must feature maximum settling zone area, great depth of water between sludge separation zone and collection point, and facilities for obtaining maximum water and reaction temperature. The various factors which come into play when a solid particle of a given size and density is supported at a given plane by virtue of an upward force created by upward water velocity and displacement in a unit, must be established.

At equilibrium, the solid particle is stationary at a given upward flow rate; the downward and upward forces acting upon it are therefore equal. The downward force is equal to the weight of the particle less the weight of the water it displaces, and can be expressed as follows:

$$F_d = V_p(S_p - S_w) \quad \text{(Eq 1)}$$

where V_p is volume of particle; S_p, density of particle; and S_w, density of water.

The upward force is equal to the difference in fluid pressures between the upper and lower side of the particle, multiplied by the cross sectional area on which the pressures are exerted, as follows:

$$F_u = (P_d - P_u)A_p \quad \text{(Eq 2)}$$

where P_d is fluid pressure on lower side of particle (in weight units); P_u, fluid pressure on upper side of particle (in weight units); and A_p, cross-sectional area of particle.

At equilibrium, when the solid particle is stationary, these two forces are equal:

$$F_d = F_u \quad \text{(Eq 3)}$$

$$V_p(S_p - S_w) = (P_d - P_u)A_p \quad \text{(Eq 4)}$$

Converting to difference in head of water flowing, the result is:

$$h = \frac{P_d - P_u}{S_w} = V_p(S_p - S_w)/A_pS_w \quad \text{(Eq 5)}$$

Equation 5 represents the net pressure drop across the particle and, neglecting friction, is seen to depend only on the particle dimensions and the densities of particle and fluid.

For flow of water or other fluid past the aperture surrounding a solid particle, in a medium of solid particles suspended at a given plane in water, it can be said that:

$$V = C(2gh)^{\frac{1}{2}} \quad \text{(Eq 6)}$$

where V is velocity of water, in feet per second; g, acceleration of gravity; h, head of water, in feet; C, coefficient of flow friction depending mainly upon viscosity of the water, and surface smoothness and area of the solid particles. The greater the viscosity, the lower is C.

$$V = Q/A_a \quad \text{(Eq 7)}$$

where Q is volumetric rate of flow, in cubic feet per second; and A_a, average

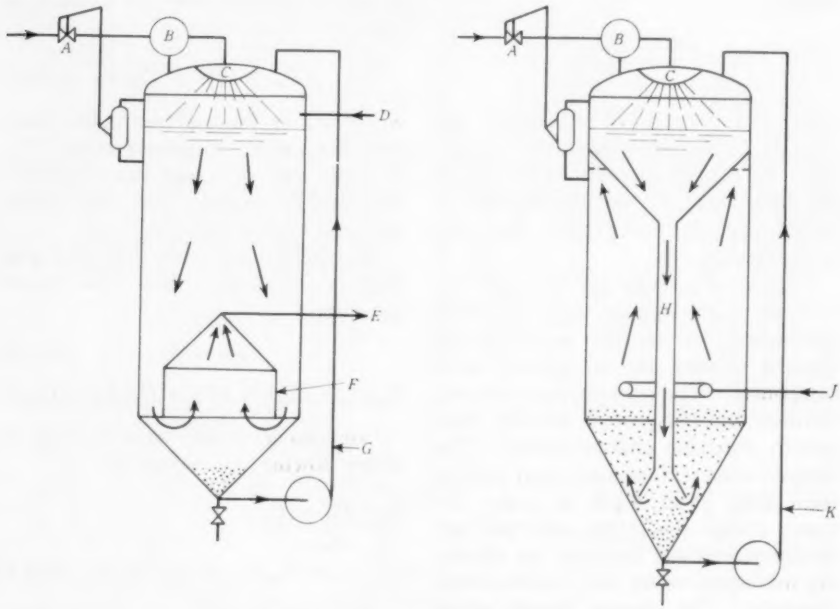

Fig. 8. Design Variations of Hot-Process Softener

In Type I, shown on the left, no contact is made with the deep sludge bed. Type II makes use of the sludge bed. Letters in the diagram indicate the following: A—*make-up control valve;* B—*vent condenser;* C—*spray valve heater;* D—*dirty filter wash water;* E—*connection to service and filter backwash;* F—*conventional uptake;* G—*sludge recirculation;* H—*downtake;* J—*dirty filter wash water recovery;* K—*sludge recirculation (when required).*

area around the edge of the particle through which the water flows upwardly.

By combining Eq 5, 6, and 7, the following is obtained:

$$\frac{Q}{A_a} = V = C(2gh)^{1/2}$$

$$= C\left[2gV_p\left(\frac{S_p - S_w}{A_pS_w}\right)\right]^{1/2} \ldots \text{(Eq 8)}$$

$$Q = A_aC\left[2gV_p\left(\frac{S_p - S_w}{A_pS_w}\right)\right]^{1/2} . \text{(Eq 9)}$$

Flow Rate to Suspended Solids

Equation 9 is the basic equation defining the relationship between the flow that will suspend a solid particle at a given plane, the properties of the particle, and the water flowing past the particle. This equation clearly shows the following:

1. The bigger the aperture, or area of water flow surrounding the solid particle, the greater the flow which can push past the particle and suspend it motionless, without carrying it up and over into the collector as turbidity.

This provides the theoretical basis for applying the principles of maintaining the very greatest area in the settling (or separation) zone, so that all of the solid particles are separated from the treated water. The flow is usually 1.5–2.0 gpm per square foot for clarification, and 1.5–2.50 gpm per square foot for softening.

2. Since all types of upward flow units have relatively large concentrations of solids of different sizes in a given space, the presence of a great height of fluid in a column through which the fluid must flow results in each particle finding its own plane of separation. This occurs only where the aperture area is large enough just to suspend the particle by difference in water pressure loss around the particle. In effect, then, a cylindrical column in which these solid particles are suspended is one in which there is an increase in average flow area between the solid particles at planes in the lower regions, where the heavier, coarser particles are found, and the lighter particles in planes at a higher level in the column. This formula merely provides the theoretical confirmation of the practical application to the clarifier, or the cold and hot-process design, of a high column of clear water above the optimum solids-from-liquid separation point and up to the effluent collector. Consequently, the design of a clarifier or softener must provide maximum depth or height of water between the sludge separation area and the collection point.

3. C, the coefficient of flow friction, is a function of viscosity of the water, and smoothness and area of the surface of the solid particles.

$$C = \frac{K}{Z_r D_p^2}$$

where D_p is diameter of particle assuming spherical shape; Z, viscosity of the water; and K, smoothness coefficient of particle.

This is the theoretical basis of the practical engineering principle, frequently applied in the field, that the lower the water viscosity, and therefore, the higher the water temperature, the greater is C, and the more flow can be pushed past the particle to maintain it suspended at a given plane. The peripheral area over which the water flows, and the smoothness coefficient of the surface of the particle, are also pertinent.

4. The greater the difference in density between the particle and the water $(S_p - S_w)$, the greater is the upward water flow which can be permitted to suspend the particle at a plane. This is a square root function. Precipitates of $CaCO_3$ and $Mg(OH)_2$ generally are heavier than most floc-turbidity combinations found in simple clarification problems. This has resulted in the development of coagulants and coagulant aids which, together with optimum pH coagulation conditions, produce floc mixtures of maximum density in simple coagulation.

5. The greater the average diameter and volume of the solid particle for a given particle density, the greater the downward force component (square root function). The reason for this is that the volume of a particle varies as the cube of the diameter, whereas the surface area of the particle, which is related to the upward frictional force, increases as the square of the diameter. This is the theoretical basis for the practical design of hot-process units where every attempt is made to increase solid particle size and thus improve settling.

Stabilization Problems

It is known, as Hartung points out, that sand filters act as solids-contact media by reducing total hardness 5–15 ppm after lime treatment in conventional or other cold-process softeners. Not as well known is the fact found by the writer that only massive doses of limestone or lime sludges in concentration of 2 to 5 per cent by weight (20,000–50,000 ppm), properly suspended for more than 10–15 min and up to 30 min, will reduce hardness 10–20 ppm within solubility product values in upflow solids contact. Hartung indicated that other factors such as presence of magnesium and effect of water temperature also influence results.

Most important of all, the writer found that while stabilization is effected under these conditions, it appears to be difficult to obtain clear water of less than 10-ppm turbidity after such contact with 2–5 per cent slurries in an upflow solids-contact unit at rates of 1.5–2.5 gpm per square foot. The problem encountered here is not stabilization, which is successful, but rather the difficulty of achieving clarification after stabilization.

The following remarks are designed to be helpful in this regard:

1. The use of upflow solids-contact equipment, required to produce clear (less than 10–30-ppm turbidity) water within 30–60 ppm of solubility product, has been found successful with warm, uniform water from wells containing very little or no organic matter (checked by chlorination) and virtually no magnesium. Even in this relatively easily reached range of approach to solubility product, organic matter and other suspended impurities, presence of magnesium or cold-water temperatures, singly or combined, tend to nullify results. It would be useful to know whether St. Louis County water had been checked for inhibitors to precipitation reactions, and whether tests were run with higher chlorine doses or chlorine dioxide to establish these effects. It must also be pointed out that water in St. Louis is generally cool in winter and contains a significant portion of magnesium which is difficult to reduce by contact.

2. It would be helpful to learn the results in the way of clarity and turbidity that were obtained at high upflow rates with the pilot plant units mentioned by Hartung.

3. It would also be helpful to know how the clarity of the pretreated, post-stabilized water compared with that of water simultaneously softened and stabilized in a single upflow unit, and if the same conclusions could be drawn from this in pilot plant and large-scale plants.

4. The writer wonders whether the degree of instability of water has a great deal to do with speed and degree of successful results obtained with such solids-contact stabilization. When approaching 10–30-ppm region, the microchemical mass action precipitation processes involved for such small amounts of precipitate may very well affect the solubility of the $CaCO_3$ sludge employed for solids contact. In other words, it would seem possible for 30–50 μ mesh preciptates to redissolve and form 5–10-μ precipitates. This would happen while stabilizing and reducing total hardness of water so that turbidity might be carried over as light floc or precipitate in addition to light magnesium and calcium precipitates.

It would seem virtually impossible to limit particle size of $CaCO_3$ precipitates to > 40–$100\ \mu$ when 3–5 per cent

sludge solids by weight are maintained in a large 40–80-ft diameter machine, where instantaneous mixing is not obtainable, and with only small amounts of fresh hardness precipitated out (10–20 ppm in the close-to-solubility product region).

5. Fine mesh precipitates of $CaCO_3$ not only reduce total hardness close to the solubility product, but also wash over the effluent. A coarser precipitate test in an upflow unit or downflow in a sand filter, as currently practiced with yearly acid cleaning, might therefore be more feasible.

6. The data in Fig. 2 and 3 of Hartung's article, showing the effect of temperature in alkalinity reduction, seem to be conflicting at times.

7. In concluding that "it was observed that the higher hardness water encountered was easier to soften to stability than softer water," the author wonders if this is true to the same final total hardness and alkalinity, and also whether other factors were variable in the raw water during this series of tests.

8. Hartung mentions the need for calcium carbonate of proper size and type for seeding purposes, and indicates that its cost may be excessive unless it can be reused for some time. The only method of achieving this is, first, to create such particles and, then, to maintain their size accurately in the desired range. It would appear that the effects of organic or inorganic inhibitors, relatively large amounts of magnesium, cold water, air temperature, as well as the difficult problem of instantaneous mixing required in all sections of a large solids-contact suspension unit, work against this ideal. The South Plant design, combining softening and stabilization in one unit with normal concentration of solids of 0.5–1.5 per cent, would seem to have much more value in helping to approach the prescribed degree of stabilization.

Hartung should be complimented for undertaking this worthwhile project. His next report is awaited with interest.

Organization and Purposes of Engineers Joint Council

E. Paul Lange

A contribution to the Journal by E. Paul Lange, Secy., Engineers Joint Council, New York, N.Y.

THIS article has been prepared in answer to many requests for information concerning the role of Engineers Joint Council in the engineering profession, and, particularly, the role of its affiliate member organizations.

The engineering profession is represented by societies formed of individual members having a common technical interest. To facilitate communication between members, local sections or chapters of national societies have been formed to operate in communities or other geographical subdivisions. In addition, there are many local or regional engineering societies composed of members from the several branches of engineering.

The technical phase of the profession has been developed to a high degree by each society, but the impact of the profession on the public requires a coordinated effort by all the segments of the profession. EJC provides the medium for this effort.

The history of EJC has been carefully documented by T. A. Marshall Jr. (*1*). The present form of EJC was derived from Engineers Joint Conference, which was composed of the presidents and secretaries of five societies. In 1945, the structure was reorganized, and the present constitution adopted, representation being drawn from the boards of the constituent societies. Subsequent to the adoption of the constitution, a committee on unity in the profession was established. On its recommendation an exploratory group, consisting of representatives of fifteen societies, studied the EJC structure. Included in the group's recommendations were modifications which would permit enlargement of the council through the addition of associate and affiliate member societies.

That engineering is a profession, is generally accepted. Unity within a segment of the profession is an accomplished fact, as evidenced by any of the national engineering societies composed of members with similar technical interests. Unity within the profession is a goal yet to be achieved.

Member societies in special fields of engineering serve their members in their specific technical areas; EJC enables the individual engineer to make the greatest possible contribution to the national welfare by promoting public recognition of the engineer.

EJC represents the individual engineer as much as it does the engineering societies which make up its membership. EJC's constitution provides for management by groups of officers, directors, and committeemen whose tenure is as brief as is compatible with efficient functioning. For these reasons, domination by any one group or

clique is precluded and representative administration assured.

EJC was established in spite of the difficulties normally encountered in the organization of federations. Strong national societies in the several fields of engineering have developed over the years. The majority of engineers, unlike individuals in other professions, are employees rather than entrepeneurs, and, as a result, hold widely differing atttitudes toward the profession and its policy toward the public.

EJC Structure

The EJC board of directors is composed of representatives who are members of the boards of the constituent societies they represent, and alternates who may or may not be members of those societies' boards—at the option of the society. This option permits wider geographical distribution of society representation. The EJC board meets regularly to consider developments affecting the engineer and the engineering profession as a whole. If the situ-

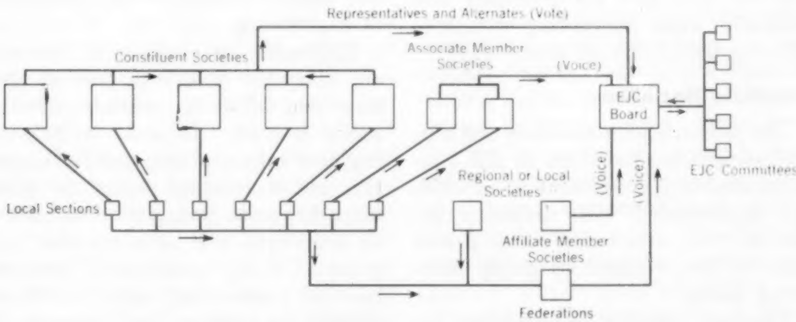

Fig. 1. Organization of Engineers Joint Council

Representatives and alternates have a vote, as members of the board of directors. Associate member societies, regional or local societies, and affiliate member societies have a voice in the deliberations of the board, but no vote.

The constitution and bylaws, under which the council functions, recognize these facts. The effectiveness of EJC in reflecting a majority opinion of the profession has already been successfully demonstrated in a number of areas.

The mechanics of accomplishing the objectives of EJC, which are continually subject to change as current conditions demand, are based on a democratic organization set up by EJC's constitution.

ation calls for a group to investigate and report, the board appoints such a committee. The committee reports to the board, which accepts or rejects the findings of the committee and takes action on behalf of the societies, in accordance with the information available. (*See* Fig. 1 for a diagrammatic representation of the organization.) A president and vice president are elected annually from among those who are currently representing, or have previously represented, a constituent

society. A secretary and treasurer are appointed to serve at the pleasure of the board. To facilitate operations, there is also an executive committee which acts on behalf of the board.

Neither the boards of the constituent societies nor their delegates on EJC react to all major problems in the same way. Various segments of the profession view certain matters differently, and one of EJC's functions is the issuance of pronouncements reflecting the majority opinion of the profession. It has been successful in this, and generally can and does act promptly and positively when compelling situations affecting the profession arise.

Associate Societies

The provisions for associate and affiliate society memberships in EJC, incorporated in the constitution in 1954, and implemented with definitive bylaws in 1955, were based on the 2-year study by the exploratory group mentioned above.

Associate member societies are national in the activity and technical interest of their members, differing in size only from the larger constituent societies. To insure adequate breadth of membership interest, the arbitrary figure of 5,000 members was selected as minimum for constituent membership. National societies, meeting all other requirements, are accorded associate status until their membership has passed the 5,000 figure.

Affiliates

The affiliate member societies are composed of either of two types of organizations, or a combination of both. One is the local or independent regional society, organized and operated for the benefit of the engineers in an area. The other, of greater importance to the readers of this article, is the federation of engineering societies, or local sections or chapters of such societies.

Since all individuals trained in the engineering profession are engineers first and specialists second, there has developed the need for an agency which will promote the one interest common to all. The federation of local sections and regional societies provides a forum for participation in affairs of public interest for specialists with that one common interest—the profession of engineering.

Engineers, as professional persons, are obligated to devote part of their time and effort to matters affecting public interest. In order to help the engineer obtain proper public recognition and professional status, the public must be made aware of him both as an individual and as a member of a group. Many community problems have an engineering aspect which requires the advice and services of public-spirited individuals within the profession. The federation provides the medium through which the public may call on the individual or the group for the service and help that it needs.

At the national level, EJC integrates the national and local societies or federations, which, when they find that the problems in their communities are similar to those in others, look to EJC to aid in finding an adequate solution.

Purpose of Federations

Technical development of the individual is essential, and is the main function of his local section. The value and benefits of such development, however, can be of material assistance to the public only if made

available to it by organized group action. Local federations act as the catalyst for the individual engineer in his relations with the public on the level with which he is most conversant—that of his community or state. This procedure is being followed at the national level through the assignment of more and more problems of public interest to EJC, with the national societies continuing their traditional role of promoting the development of the profession in their field. A similar separation at the local level permits flexibility in the activities of a local group without posing the legal problem of the right to take part in local, state, or regional legislative matters.

Some national societies have instructed their local sections or chapters that they cannot, as an integral part of such a national organization, take an active part in local, nontechnical matters. The reason for this is that the actions of a local section might be construed to be a reflection of the policy of the national organiza- with respect to the specific local situation, particularly where such a local problem might easily have a national connotation.

Positive action which can be taken by national societies on legislative matters is limited by the strict regulations of the Bureau of Internal Revenue. All member societies of EJC have requested, and have been granted classification as nonprofit organizations under the Internal Revenue Code, Section 501(c)(3). This section permits individuals to make tax-free gifts, bequests, or donations to the societies. However, if the societies should devote a substantial part of their activities to attempting to influence legislation by propaganda or otherwise, this privilege would be rescinded and the other advantages of this classification would be lost.

Although EJC itself is also a nonprofit organization, it is classified under Section 501 (c)(6), which is defined in the code as a "business league." Gifts or bequests made to a business league are taxable to the donor. The activities of a business league may be directed to the improvement of business or professional interests of the organization.

The line of demarcation between activity in the legislative field and lobbying is not clear cut. However, from discussions with the bureau, it would appear that activity in the legislative field refers to interest in the policy inherent in the legislation, while lobbying is construed as positive action taken on a specific item of legislation. EJC has a long established and well defined interest in policy contained in legislation affecting the engineering aspects of the development of the country, but in no instance has it taken a positive stand on a specific item of legislation.

Local federations, whether state or regional, if formed and operated along the same pattern as EJC, would probably be permitted the same latitude of action within their fields of interest. Each case must be examined on its own merits.

A federation of local engineering groups could be a simple answer, since a federation is in itself an entity. A federation is composed of duly elected or appointed representatives from each of the local groups, and the policies of the federation are an accurate reflection of the policies of the member engineering groups. Each local section, chapter, or independent society con-

tributes a nominal amount for the financial support of the federation. Declarations of policy are the right of the federation, rather than of its individual components, for the federation is the reflection of unity, and the validity of the axiom, "In unity there is strength," must be apparent.

Federations and EJC

The relation of EJC to this picture is simple. A local federation enhances its effectiveness by becoming an affiliate member society of EJC. A national policy has no value unless it has the support of the local members, and the individual engineer cannot know accurately what the national policy actually is and how it may affect the community in which he lives except through group action.

The question has often been raised concerning the advantages of dual representation in EJC—one through regular membership in a national society with the society board representatives speaking for their members at the EJC Board, and the other through an observer from a federation which has a voice at all meetings of the EJC board and a vote at the annual meeting of the board. Each serves a specific purpose. The national society board member reflects the considered opinion of the majority of the members at the national level, while the observer from the federation brings to the EJC board the specific policy problems of the area which he represents. The opinions of each are essential to the establishment of satisfactory basic policy that will be value and benefit to the profession and the public which we serve.

Conclusion

Science is continuing to provide engineering with ever-expanding vistas. The utilization of new metals, the applications of nuclear phenomena, the harnessing of the vast store of solar energy, and electronic and mechanical developments in automation, increasingly invest the engineering profession with social as well as technological responsibilities. The activities of this influential and representative federation of engineering groups, striving to bring to bear the weight of the entire profession on these problems should stir the imagination and enlist the support of every engineer.

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Copper Dissolution Caused by Stray Electric Currents

Raymond E. Ebert

A paper presented on Nov. 15, 1955, at the North Carolina Section Meeting, Winston-Salem, N.C., by Raymond E. Ebert, Supt. of Water Supply, Winston-Salem, N.C.

IN the area of water quality complaints, it is not unusual to find new problems that are of a localized nature. In February 1953, a call was received which described a bluish sediment in a householder's refrigerator water bottle. The colored, settled substance in the water was identified visually as a copper compound, and later laboratory analysis confirmed the presence of an unusually large quantity of copper.

It was decided that the possible causes of the trouble included inferior pipe, galvanic corrosion, and stray, electric currents. In order to investigate the problem properly, it was necessary to know whether the trouble was localized within the house or present, as well, elsewhere in the neighborhood. Inasmuch as similar complaints had not been received, and water which had been sampled from the water main, through a fire hydrant in front of the house, showed no copper at all, it was evident that the copper was coming from the copper service pipes within the house.

Every suggested possibility was considered as a basis for study, until each was eliminated either logically or by water analysis. First considered was the possibility that the house had been piped with an inferior grade of copper. The plumber who installed the house plumbing identified the local supply house which had provided the original plumbing material. In an interview with their representative it became clear that even in times of material shortages all copper pipe is manufactured under rigid specifications and, hence, the possibility of inferior material was inadmissible.

The chance that bimetallic connections were causing galvanic corrosion was then investigated. The plumbing was easily accessible for study, and a thorough inspection revealed nothing resembling a galvanic cell. Following this inspection of the water pipe, it was thought that taking samples at all the taps in the house, both hot and cold, would indicate whether the condition was occurring at one spot or throughout the house plumbing.

Samples were collected from the kitchen, bathroom, basement, laundry, and outside spigot, both mornings and evenings. Although the copper content of this sampling was different in the morning from that of the evening sampling, all samples collected throughout the house at the same time showed approximately the same content. With this information it was apparent that the copper was coming from the entire plumbing system. It also strengthened the belief that the trouble was being caused by some kind of electrolytic action. In searching reference material on stray-current corrosion, it was

found that this type of corrosion was caused almost entirely by the flow of direct current. One source says: "Damage from alternating current of commercial frequencies is on the order of 1 per cent of the damage produced by direct current of the same magnitude. In view of this, stray current is usually associated only with direct current" (*1*).

Further study of the copper content of the water was undertaken, and water samples were collected from the kitchen faucet at frequent intervals throughout the day. These samples were taken from early morning, before any water was drawn from the spigots, until evening, and showed a wide variation in copper content throughout the

TABLE 1

Copper Concentrations During 12-hr Period

Sampling Time	Copper—*ppm*
7:00 AM	7.0
7:30 AM	1.4
9:30 AM	0.3
11:30 AM	0.2
2:30 PM	1.5
6:30 PM	0.2

sampling period. Some samples contained as much as 7 ppm copper, and others showed as little as 0.2 ppm. (Table 1 shows the results of sampling.) The wide variation of copper content in the water over a 12-hr period indicated that the corrosion was probably continuing at a fairly constant rate. With variable usage of water through the day it would be possible for copper to accumulate in the pipe at night, with consequent release of a large quantity in the first water drawn from the spigot in the morning. It was the custom of the housewife to fill the refrigerator bottle before breakfast, and this accounted for the blue sediment of copper compound found in the bottle.

Stray-Current Corrosion

The study was then focused on the possibility that stray-current corrosion took place along the interior of the copper piping. All of the ground connections thought capable of carrying a d-c flow of electricity were disconnected from the water pipe and grounded directly. The television set and the telephone were the only potential sources of direct current found. The television set was already grounded to a stake next to the house foundation, and, upon request, the telephone company shifted its ground wires from the water pipes to a rod sunk nearby.

Regular daily sampling was continued for two weeks more, in the hope that the quantity of copper would show some appreciable decrease. No favorable change occurred and it was clear that the telephone ground could not be causing the trouble.

The only remaining possibility was that the trouble was caused by imbalance in the 115 v a-c system through a ground from one of the house appliances.

If an electric current were being carried by the water pipes it would be detectable by an appropriate measuring instrument, and one of those used was a hook-on ammeter. This was used first on the copper service pipe where it entered the basement. A reading of 0.5 amp was recorded immediately, followed by a sudden increase to 0.7 amp, while grounds to the pipe were being removed. This increase occurred at the moment that a refrigerator began to operate. It was con-

cluded that if it were possible to reproduce this condition by the starting of other electrical appliances, the trouble might be isolated, since there would be a corresponding increase in the reading as more appliances were started. Conversely, as the switches were cut off, the readings would decrease to a minimum of 0.5 amp. One seemingly unaccountable phenomenon, at the time, was the occasional fluctuation from 1 amp to 0.5 amp without the starting of any appliances. In turning on and off the electrical load, it was observed that the electric hot-water heater could not be shut off because of the lack of a separate, fused switch. When the main switch was opened, the wire removed from the water heater circuit, and the switch reconnected, the ammeter remained at zero. When the water heater was reconnected, the ammeter immediately indicated current flow. Examination of the electrical connections of the heater revealed a naked wire resting against the meter's side. Removing this wire produced a meter reading of zero. In order to recheck the results, all electrical fixtures were placed in service. This electrical loading indicated no passage of current in the water pipe system.

Final Test

The final test came the following day when the water was again sampled and tested for copper. It was expected that the water would be free of copper, but a sample from the kitchen sink showed a content of 3.75 ppm. It was assumed that perhaps the interior of the pipes were raw from the recent dissolution that had been taking place. Later tests were made at convenient intervals at the kitchen outlet and a regular fall in the copper content was shown (Table 2). The house occupant reported after the last sampling period that the water was free of any visible copper.

TABLE 2

Drop in Copper Concentration Following Elimination of Stray Currents

Date (1953)	Copper—*ppm*
May 14	3.2
May 26	1.1
Jun. 12	0.6
Jun. 28	0.02

Reference

1. Uhlig, Herbert H. *The Corrosion Handbook.* John Wiley & Sons, New York (1948).

Legal Aspects of Water Works Operation in Illinois

Melvin S. Rembe

A paper presented on Mar. 23, 1956, at the Illinois Section Meeting, Chicago, Ill., by Melvin S. Rembe, Technical Advisor, State Dept. of Public Health, Springfield, Ill.

THE State Department of Public Health in Illinois has frequently been requested to interpret or construe particular provisions of the Public Water Supply Control Act (Par. 121a–121n inclusive, Chap. 111½ of the *Revised Illinois Statutes*) and its application. It seems appropriate, therefore, to review the pertinent provisions of the act, and to consider the minimum standards required by the department in the application and enforcement of these provisions.

The Public Water Supply Control Act (Par. 121a–121n, Chap. 111½) was enacted to provide specifically for the supervision, control, and regulation of all public water supplies as authorized under Sec. 55.03, Civil Administration Code (Par. 55.03, Chap. 127).

The act is primarily a police power legislation, and must be interpreted with this in mind. The title alone expresses this fact—An Act to Provide for Safeguarding the Public Health by Vesting Certain Measures of Control and Supervision in the Department of Public Health Over Public Water Supplies in the State. The act constitutes the exercise of the state's sovereign police power by vesting the supervision and control of all public water supplies in the State Department of Public Health.

The law has many aims, but none more important than the preservation of public health. The dangers of spreading contagious infection by water are great. It is of primary importance, therefore, that the state exercise this police power to secure potable and uncontaminated water from all public water supply systems. Generally speaking, legislation enacted under the police power intended and calculated to accomplish these ends is not subject to judicial review.

In *Taylorville Sanitary District* v. *Winslow* (*1*) the court, in discussing this police power of the state where it relates to preservation of health, said:

> The General Assembly may, either by direct enactment or by delegation of power to public corporations, provide for the preservation of health as a proper exercise of police power. . . . There is to be included under this power the making of sewers and drains, the boring of wells, the construction of aqueducts for the procuring of fresh water supply, the drainage of malarial swamps and the erection of levees to prevent overflow.

Creation of Water Authorities

Under this inherent police power of the state, the supply, withdrawal, and the use of ground waters of the state can and should be regulated and controlled, particularly during periods of extreme drought or water shortage. Though such legislation has been in effect in a number of our southwestern states for a great many years, it has been but recently (1951) that such

proper and appropriate legislation has been enacted in Illinois. The statute is known as "An Act to Provide for the Establishment of Water Authorities . . ." (Par. 223–232, Chap. 1112–3 of the *Revised Statutes*). This act, though not as yet utilized by many counties of the state, provides for the creation of a water authority having power to carry out any of the following measures: require the registration of all wells or other withdrawal facilities; grant permits to dig wells; regulate the use of water; inspect wells and require the plugging of those abandoned; establish limits on priorities as to use of waters; levy and collect a general tax on all taxable properties within the corporate limits of the authority, to be used for its own benefit.

In view of the general water shortage, mounting industrial needs and future needs of the growing unincorporated acres, it is obvious that the creation of these water authorities is inevitable in the very near future.

Similar powers to control and regulate public water supply were conferred on township government by Par. 39.14, Chap. 139 of the *Revised Statutes*. Town authorities were allowed to: "construct and keep in repair public wells or other watering places, and regulate the use thereof."

It is the purpose of these prefatory remarks to emphasize the manifest necessity of these inherent police powers.

The first section of the Public Water Supply Control Act (Par. 121a, Chap. 111½) specifically defines public water supplies as follows:

> Public water supply means any facilities for furnishing water for drinking or general domestic use through a system of distribution mains in incorporated municipalities, state-owned parks and memorials, state-owned educational, charitable, or penal institutions, and unincorporated communities where ten or more separate lots or properties are served.

The mention of "any facilitites for furnishing water" indicates that the source of the water may be from either surface or ground water through a "system of distribution mains." This includes mains in incorporated municipalities not only within the corporate limits but also to the entire public water supply system of the municipality within 10 miles of its limits, as far as the water works extend as provided in Sec. 75.3 of the Revised Cities and Villages Act (Chap. 24, *Revised Statutes*). The validity of this last provision has been upheld in *Chicago Packing and Provision Co.* v. *City of Chicago* (*2*), and more recently in *City of West Frankfort* v. *Henry Fullsop* (*3*).

Under the Cities and Villages Act, Sec. 82–15, any water company supplying any municipality has the power and authority to locate its source of supply at any point within 20 miles of the municipal corporate limits. Section 82–16 grants the right of exercising the privilege of eminent domain for construction, maintenance, and operation of necessary pipelines to the source of supply. The water company has the power and authority to protect the source of supply, reservoirs, and other appurtenances from contamination, pollution or damage.

Regulation of Contamination

In unincorporated areas, the contamination of a source of supply can easily be dealt with as a private nuisance. State or local officials, however, must first determine that there is sufficient evidence of a public nuisance. Furthermore, companies in unincorporated areas may institute criminal prosecution against the perpetrator

by virtue of Sec. 82–17 of the Cities and Villages Act. The abovementioned sections grant water companies broad supervision and protection of the complete water system.

The Attorney General in interpreting the word "system" as used in this section, stated:

> It would therefore seem that the use of the term system in Par. 121a implies that said distribution mains are connected with the municipality's water works or other source of supply of water to the municipality. In such case, there is no requirement that ten or more separate lots or properties be served, in order that the facilities for furnishing water constitute a public water supply.

This Par. 121a further defines a public water supply as "unincorporated communities where ten or more separate lots or properties are served." This must necessarily include all subdivisions in unincorporated areas consisting of ten or more separate lots or properties being served by a common water supply system, whether such lots are being leased or conveyed by deed in fee. It would also seem that the homes built on the leasehold estate are properties within the intent of this paragraph.

The first part of Sec. 2 of the Public Water Supply Control Act (Par. 121b, Chap. 111½) provides that:

> Owners of public water supplies, their authorized representatives, or legal custodians shall submit plans and specifications to the department and obtain written approval before construction of any proposed public water supply installation, changes, or additions is started. . . .

Primary attention is directed to the provision that plans must be submitted and approved by the department *before* construction is started. The statute is very clear and specific in this respect. Regrettably, it has been necessary for the department to request the state's attorneys to prosecute several violations of this provision of the act. This is an extremely pertinent and important provision of the act, making it incumbent upon the department to secure its enforcement. The department is reluctant to institute litigation for such violations, and every effort is expended to secure the cooperation of all agencies in complying with this provision.

Section 2 further provides that, at the time plans and specifications are submitted for approval, "said plans and specifications shall be accompanied by supplemental data as may be required by the department to permit a complete review thereof." In order to assure the continuous operation and maintenance of all proposed public water supply systems, it becomes necessary, therefore, that, at the time specifications are submitted, satisfactory evidence be produced of the *continuous* maintenance and operation of the proposed public water supply system. This may be done by a certificate of convenience and necessity issued to the public water supply agency when it is evident that the company comes under the jurisdiction of the commerce commission. When the public water supply is not a public utility, however, it is necessary that other satisfactory evidence of its continuous operation and maintenance be produced. In the past, the department has encountered numerous occasions in which the subdivider, having installed the well, pump, and water system and sold all properties, has abandoned the system, leaving no corporate entity with authority for future operation and maintenance.

The last part of Sec. 2 of the Public Water Supply Control Act provides that: "plans and specifications shall be

prepared only by such persons as may be permitted by law." It may be well to clarify this language and set out what is required by the department under this provision.

Section 1 of the Act to Regulate the Practice of Professional Engineering . . . (Par. 32 of chap. 48½, *Revised Statutes*) states that: "it is unlawful for any person not so registered to practice or offer to practice professional engineering in this state. . . ." The Section further states that: "a person practices professional engineering, within the meaning of this act, who plans or designs the physical parts of . . . water works, sewers, or sewage disposal works. . . ."

In order to obey the law, the State Department of Public Health can thus only accept specifications prepared by a registered engineer.

Sections 7, 8 and 9 of the Public Water Supply Control Act provide for the operation and maintenance of public water supply systems, and the manner of collection and submission of water samples for analysis as directed by the department. The language is clear, and there is no necessity for further interpretation.

Section 10 of the act (Par. 121j, Chap. 111½) is specific; it demands that whenever the department investigation establishes that water from any public supply "is not safe or is *subject* to contamination," the owner or official custodian shall "take immediate action to correct sanitary defects" by improving operation, providing necessary treatment, or making any other changes to provide assuredly safe water.

Need for Immediate Action

It should be noted that immediate action is necessary as a water company will not be exonerated or freed from liability to consumers by posting notices announcing water to be impure or dangerous. By the same token, a public water agency is not free from liability even though no health department or official agency has given warning of a dangerous condition of the water.

It is difficult to understand the reluctance of a public water agency in taking immediate corrective steps to improve water quality. It is the duty of a water utility, after all, to supply safe water. Negligence which can cause personal injury or death is unforgivable.

The courts seem to hold that when a municipality undertakes to supply water for domestic, commercial, and industrial uses, it acts in a proprietary rather than governmental capacity, and that in a proprietary capacity, the municipality is liable for the acts or failures of its servants just as is a privately owned water company (*4*).

A brief review of two Washington cases (*5, 6*) may be informative in determining a definition of negligence and sufficient notice.

Both involved deaths from typhoid, and the facts concerning the water supply were the same. The water distribution system of the city had been polluted by the mains of a mill on a river. The plant had been connected with the city water system prior to 1923. As the river water was unfit for human consumption, it had not been permitted to enter city mains. A check valve had thus been placed in the company line, but a bypass with a gate valve had been installed around the check valve. A new main was installed in 1923 to increase the supply of city water to the mill. The *normal* pressure in the city mains was *higher* than that in the company system. Later that year, an epidemic of typhoid fever broke out in the city, prompting

an investigation which disclosed that the gate valve on the mill bypass line was open, and that the pressure in the city main had been *reduced* below that in the company mains by heavy use of city water for lawn sprinkling. Polluted river water from company mains was thus introduced into the city distribution system. Complaints had been made to the city officials early in 1923 about the smell and appearance of the water. It was alleged that it had induced illness. Complaints continued until the time of the typhoid epidemic. Verdicts against the city were sustained on appeal.

It is obvious that there was negligence in the installation of a cross-connection between the polluted and potable supply, and in the failure to make a prompt investigation following complaints—both excellent examples of positive negligent actions. The need to take steps immediately after notice of possible contamination is emphasized. Contamination is defined as: "A general term signifying the introduction into water of micro-organisms, chemicals, water, or sewage, which renders water unfit for its intended use" (*7*).

It is not necessary that actual contamination exist; the fact that certain apparent conditions could subject such waters to contamination is sufficient to require the immediate correction of the faulty condition. In the Washington cases just mentioned, the cross-connection fell within the "subject to contamination" definition.

Hearings and Penalties

Section 11 of the Public Water Supply Control Act (Par. 121k, Chap. 111½, *Revised Statutes*) provides that, in the event the owner or official custodian fails to correct conditions mentioned in the section immediately, the director of the department shall call an administrative hearing to give the owner an opportunity "to show cause why sanitary defects should not be corrected or operation of the water supply improved in order to make the water assuredly safe." If, in the opinion of the director, such cause is not shown, he will "order in writing any such corrections, changes, or additions, to be made as may be necessary to provide assuredly safe water." Should the owner disobey the order, the attorney general may institute mandamus * proceedings to enforce compliance.

Violation of any provision of the act carries a maximum fine of $1,000 or 5 year's imprisonment or both. In a violation of the act, the penalty clause may be invoked before the findings of the administrative hearings are available.

It is gratifying to the department to observe that up to the present day, it has not become necessary to call an administrative public hearing to compel the correction of any contaminated public water supply, and it is the constant hope of the department that agency efforts to appreciate and overcome public health hazard will continue.

References

1. *Taylorville Sanitary District* v. *Winslow*, 317 Ill. 25, 31.
2. *Chicago Packing and Provision Company* v. *City of Chicago*, 88 Ill. 221.
3. *City of West Frankfort* v. *Henry Fullsop*, 6 Ill. 2nd 609.
4. McQuillin, *Municipal Corporation*, Callaghan & Co., Chicago (1954) p. 1194.
5. *Aronson* v. *Everett*, 136 Wash. 312.
6. *Roscoe* v. *Everett*, 136 Wash. 295.
7. *Glossary—Water and Sewage Control and Engineering*—American Society of Civil Engrs. (1949) p. 46.

* A court order to a corporation or person to enforce the performance of some public duty.

Reducing Unaccounted-for Water by Continuous Leak Survey

Howard W. Niemeyer

A paper presented on Feb. 8, 1956, at the Indiana Section Meeting, Indianapolis, Ind., by Howard W. Niemeyer, Supt. of Distribution, Indianapolis Water Co., Indianapolis, Ind.

WASTE of water has coincided with the development of water supplies and has been an ever present problem for the water works man. While much attention has been given to this problem over the years, the control of water waste has greater importance today than ever before. A steady growth in population during an era of vast economic and social changes has been responsible for a rapid and apparently unending rise in water use. In the past several years, many utilities have experienced difficulty in keeping pace with the soaring demand, and water shortages have occurred during periods of peak use. Impounding reservoirs have been created, new sources of supply developed, plant facilities enlarged, and distribution systems reinforced—all at great cost—in order to overcome actual or impending deficiencies. Under such conditions, there has been a diminishing tolerance for water waste and an increasing need that all available water be channeled into useful purposes. It is unfortunate if waste has been responsible for shortages that have occurred, and it is illogical if costly facilities have been provided to support excessive water waste.

Definition

In the early days of flat-rate service, water waste was defined as that portion of a supply which was not delivered to consumers to serve a useful purpose. This definition was necessarily broad in order to cover careless use of water by consumers as well as the leakage from plumbing systems. With the metering of all services, we have come to think of waste as that portion of the supply that is delivered into a distribution system and which cannot be accounted for. Actually, unaccounted-for water is not all waste but will include used water that is not paid for. Also, water accounted for will include true waste by a customer to the extent that he is willing to pay for it. In discussing the control of waste in a fully metered system of a supply, consideration has to be given all phases of loss.

The problem of determining the amount and location of unaccounted-for losses, and effective yet economical means of controlling them, is not a simple one, readily solved. The many factors contributing to the problem are so integrated that no one factor can be identified as a source of major loss, making it difficult to take specific action to eliminate it. A sound loss-control program starts with an accurate accounting of the supply delivered, with attention to the following phases of the problem:

1. Measurement of supply delivered into system

2. Consumers' meters
3. Unmetered uses from hydrants
4. Operational waste
5. Theft of water
6. System leakage.

The amount of unaccounted-for water resulting from the operation of a distribution system is established by determining the difference between the measured flow into it and the amount delivered (represented by a summation of the consumers' meter registrations to which has been added a reasonable estimate of unmetered uses). It is obvious that the reliability of this figure depends upon the accuracy of the metering devices and the accuracy with which the unmetered uses are estimated. Unfortunately, the consumers' meters have to be read on a staggered basis, and, because of variable reading dates, the summation of consumers' use never corresponds to the periods of recorded measurements of the master meters. Even annual comparisons do not provide exactly corresponding periods of delivery and use, although they are sufficiently close to provide good data on waste.

The need for accurate measurement of the input into a system is of sufficient importance to warrant repeated emphasis. Inaccuracy of this measurement creates a false accounting of waste which may misdirect and confuse efforts at control. Under-registration of the master meters will indicate less waste than is actually occurring and can lead to complacency. Over-registration will, conversely, indicate nonoccurring waste which, in turn, may lead to unnecessary survey expense. The devices to be used for master metering should, therefore, be selected with careful regard for their accuracy over all ranges of flow. After installation, these devices should be regularly checked, at a frequency determined by experience, to maintain them within their designed accuracy limits.

The inaccuracies of consumers' meters are often responsible for a major share of the unaccounted-for water. The best insurance against excessive loss from under-registration of meters is sound meter practice. Meters should be carefully selected as to type, size, and quality for the services on which they are to be used, and the accuracy of their registrations should then be carefully preserved by efficient reading and by adequate maintenance programs. In this regard, reference should be made to the many excellent articles that have appeared in the JOURNAL on the subject of meters. The effectiveness with which meters control leakage and waste in consumers' plumbing is determined by their efficiency. According to the concept of a fully metered system, all services should be metered, including uses by utilities' own plants, as well as free services that may be provided for public use. This should be done for financial as well as water accounting purposes.

Unmetered Use

Unmetered use of water which is drawn from fire hydrants is normally not as great as assumed, and it is frequently overestimated, with a consequent false reduction in unaccounted-for water. Such uses should be estimated on the basis of frequency and duration rather than by some arbitrary and fixed percentage of the input into the system. For instance, water used for fire fighting can be closely estimated from records of the fire department on the number of fires occurring, their duration, and the number of hy-

drants used. Water used for street cleaning can be established by the number and size of street flushers in use and their frequency of operation. To obtain a realistic figure for unaccounted for water, these unmetered uses must be taken into consideration by conscientious estimates of their amounts. It has been the experience in Indianapolis that unmetered uses represent no more than 0.5 per cent of the annual pumpage.

Some unavoidable water waste occurs in the normal operation of a distribution system. Some examples are waste resulting from flushing of mains, antifreeze bleeding of mains, flow tests of the system, hydrant testing, cleaning of elevated tanks, and losses associated with routine repairs to the system. Much of this waste can be estimated within reasonable limits and properly charged against operations to reduce the unaccounted-for amount. Open hydrant discharges are determined by use of the pitot blade and a record of the duration of opening. A reference table can be used to convert pito pressures into discharge rates, in order to calculate the water used. Some of the unavoidable waste can not be readily measured and will appear in the unaccounted-for figure. Here again, the amount of unavoidable waste occurring will normally be found to be only a fraction of 1 per cent, except in unusual cases such as systems requiring abnormal flushing to maintain water quality.

Theft of water is always an unknown quantity that requires constant vigilance to minimize. Consumers can obtain water service without benefit of payment by any one of several means: connections to unmetered fire protection plumbing, connections to service lines ahead of meters, installation of jumpers in meter connections, tampering with meters, or taking water from fire hydrants. The theft problem should be recognized and every means provided to discourage it or make it impossible. Many utilities require the installation of a detector type meter in all fire protection services. Sealing of meter registers and their connections provides good insurance against tampering. Regulations should require the inspection of underground pipes before they are covered and at the time of installation. An alert meter-reading force probably provides one of the best means of detecting theft of water, since the readers are constantly patroling the consumers' premises. Their knowledge of water consumption by all types of customer allows them to make comparisons between similar types of users and to detect unusually low consumptions which may indicate theft. This group should be suspicious of nonusers of the utility's service who are adjacent to distribution mains. All suspicions should be carefully investigated if this type of loss is to be controlled.

The several factors influencing the problem of unaccounted-for water have been briefly discussed up to this point. Their bearing on the problem is quite important and none of them should be ignored if sound water accounting practices are to be followed. The most important loss of water, however, results from underground leakage from the distribution system. This loss is true waste, not only waste of supply but also waste of storage, purification, pumping and distribution. The control of such waste is a continuing problem which requires the establishment of routines for the prompt and continuing detection and elimination of leaks.

Service lines and pipelines are subject to many stresses which cause leaks. They expand during warm cycles and contract during cold; they are subject to external loading from other structures, and their position is shifted by soil movements caused by settlement or dehydration of the surrounding soil when the surface becomes ice crusted. Defects or weak points in the line give way and leaks develop. Many of these will surface and be readily detected by passers-by. Many will not surface, however, because of adequate underground drainage provided by adjacent sewers, crevices in rock, or a gravel stratum. These nonsurfacing leaks, if allowed to multiply, can constitute a major part of unaccounted-for water. One large pipe break alone can account for a high percentage of a day's pumpage, and the waste from a large number of small leaks may be equivalent to that of one large break. No leak is too small to be found and repaired, and the economical time to repair any leak is at its time of origin. Leaks never get smaller; instead, they continue to grow in size, extending their waste and often causing damage. In many instances, leaks will undermine pavement, creating a public hazard, or penetrate a basement to damage property or merchandise. Damage is often done to adjacent structures of other utilities. Whenever a small leak has been repaired, a potentially large leak has been eliminated, with a considerable saving in water and possible damage costs.

Detection of Leaks

Fortunately, water escaping from an orifice under pressure sets up vibrations that are transmitted to the ear as sound. These vibrations will be transmitted by metallic pipe for varying distances, depending on the composition of the pipe, its size, and the size of the leak orifice. Through the years, this phenomenon has permitted man to detect the presence of subsurface leaks with varying success, depending on the intensity of the sound and the hearing ability of the individual. Devices giving mechanical amplification to the leak sounds were developed to increase man's proficiency in detecting leaks. The aquaphone and the stethoscope type detector are examples of these hearing aids. With the development of the vacuum tube, electronic amplification was applied to leak detection devices and the listening range was expanded many times. The electronic-type detector is available in sizes with varying sensitivity, from small, compact hand sets called "midgets" to large-size, highly sensitive detectors that must be transported by vehicle. The type of equipment to be used should be determined by the size of the distribution system to be surveyed, and such local conditions as hydrant spacing, size of pipelines involved, and other points.

Leak surveys can be made by any listening means, but the sensitivity of the equipment used will determine the spacing required between points of contact with the system. Without the aid of an amplifying device, it is necessary to make actual listening contact at all hydrants, service stops and valves to obtain an accurate survey. With sound amplification, the number of contacts required will be greatly reduced, with resulting savings in work and survey time. It has been found that adequate surveys can be made with a highly sensitive detector by contacting hydrants only, except where they are widely spaced or con-

nected to large mains. Large-diameter pipe will not transmit sound any great distance, and when encountered, intermediate contact points must be used. The same is true when hydrants are widely spaced. Long transmission mains without either hydrant or service line connections should have covered-riser pipes installed over them at frequent intervals between valves, to serve as survey contact points. Since the largest part of a distribution system is composed of small-diameter pipe, the hydrants alone will provide all but a very small percentage of the contacts required for a survey when sensitive detection equipment is used.

The frequency with which a system should be surveyed is determined by the experience of the utility with respect to the number of leaks that normally develop, and the character of the subsurface as it affects the surfacing of leaks. The amount of unaccounted-for water occurring should not necessarily be a factor in survey frequency, since the purpose of continuous, leak surveying is to detect leaks as they develop, rather than after they have accumulated and grown into major causes of waste. Certainly, all systems should be surveyed annually, at least.

As previously indicated, the high-amplification detector has a decided advantage because surveys are made in less time than by any other method, and because of the minimum number of listening points required. Further economies can be effected by incorporating the leak survey with an annual hydrant testing program. The leak detection work adds but little time to that of the hydrant inspection as it involves only that time necessary to fix a microphone to the hydrant and to listen briefly. This plan saves the travel time necessary for a separate leak survey. Except when major leaks are indicated, a log can be made of leak indications obtained, and these can be traced to source at completion of the hydrant program. Leak sizes are easily distinguished by the tone and the number of hydrants on which the sound is heard. Small leaks are usually picked up on one or two hydrants, and major leaks will be heard on one or two hydrants in each direction from the location of the leak. Major leaks should be traced as soon as detected.

Tracing

The detection of leaks is the first and simplest phase of a survey program. The second step is the tracing of each leak indication to its source, and this work requires the skill and experience of trained personnel. Many leaks will be found to have their origin in a hydrant which may have been incompletely closed by its last user. The hydrant valve may be faulty, or the hydrant base joint leaking. Leaking hydrant valves can be quickly determined by the use of a periscope flashlight. Other leak indications are traced by listening on service line stops adjacent to the hydrant on which they were heard. In most cases, one of the service lines contacted will prove to be the source of the leak. Main leaks can be spotted *approximately* by experienced survey personnel by sound tone and by instrument readings. The leak can be *exactly* spotted by driving probe bars to contact the main for further reading, or, in some instances, by using the microphone directly on the pavement over the main.

To provide even closer control on leak waste, it is well to supplement the

instrument survey of a system by regular service line policing by the meter reading personnel. Generally, 80–90 per cent of all leaks occurring in a distribution system will be in service lines. In total, service lines can waste a significant amount of water if undetected, and a "listening-in" inspection on each, when the meters are read, will hold such waste to a minimum. Also, many major leaks have been found and repaired by alert employees suspicious of sunken pavement over main locations or of water running in storm sewers during dry weather. It is worth while to train all employees to be leak conscious and alert to any indication of waste.

It has generally been considered that unaccounted-for water should not exceed 10 per cent of the input into a well-maintained system. This appears to be a quite generous allowance, when one considers that 10 per cent represents 1.2 months of a year's pumpage wasted, for which no revenue has been received. If a waste control program of any utility fails to keep the unaccounted-for figure within this allowance, then a more detailed examination of the system, such as is provided by a pitometer survey, should be made. Such a detailed examination would uncover theft, gross underregistration of meters, or major leaks that might have been missed by routine detection practices.

Correction

The paper "Relation of Treatment Methods to Limits for Coliform Organisms in Raw Waters," by Graham Walton (October 1956 JOURNAL) contained an editorial error. On p. 1282, Col. 1, the author stated that the densities of coliform organisms in raw waters were obtained by *presumptive* tests of single-tube plantings in decimal dilutions, and were expressed in terms of the "indicated number" (Phelps' index). By the term "indicated number" the author meant "the number obtained by taking the reciprocal of the highest positive dilution in a decimal series." (This is substantially the definition appearing in the ninth edition of *Standard Methods.*)

In attempting to define this term, the editors inserted a footnote referring to "the reciprocal of the *confirmed or completed* findings," the authority for this phrase being the *eighth* edition of *Standard Methods.* The editors' footnote thus contradicted the author's text, a result which the editors sincerely regret. (To add further confusion, the word "confirmed" was misspelled "conformed" in the footnote as published.)

The question of the apparent discrepancy in the definition of "indicated number" in the eighth and ninth editions of *Standard Methods* (the new tenth edition does not use the term) is being referred to the appropriate committee.

1956 Diamond Jubilee Conference—St. Louis

SAINT LOUIS, where AWWA was born 75 years ago, welcomed the Association back home for its Diamond Jubilee celebration last May 6–10, and the homecoming was really something to be jubilant about. Jubilating were more than 2,500 members and guests on hand to salute AWWA's past, to hail its future, and to make the most of a present that offered an unparalleled treat of technical sessions, exhibits, inspection trips, and entertainment keyed to the Association's 75 years of achievement. Center of the celebrating was Kiel Auditorium, which offered exceptional facilities for not only the work but some of the play. Meanwhile, some of the ten hotels which housed AWWA anniversarians and many of the city's famous places helped in the entertaining.

Chief Celebrant for this biggest week in AWWA's history was Victor Weir as head of a Convention Management Committee which gave him as lieutenants:

Representing AWWA	*Representing WSWMA*
Vance C. Lischer	Louis F. Frazza
Thomas J. Skinker	Thomas T. Quigley

Ex Officio

Frank C. Amsbary Jr., *President*	J. A. Frank, *President*
Harry E. Jordan, *Secretary*	John G. Stewart, *Manager*
Richard Hazen, *Chm., Publication Com.*	

Around an anniversary session that presented Abel Wolman, Sherman Chase, and John Murdoch as the official AWWA historians, Dick Hazen's Publication Committee built a full program of sixteen technical sessions that put their emphasis on the present and future of the Association and the industry. A complete list of the papers presented appears on pages 1568–70; practically all have been published in the Journal, where they may be located by reference to the annual index (see pages 1593–1610).

John Stewart's Exhibit Committee helped create the anniversary atmosphere, too, with a record 182 boothsful of equipment and materials that traced the growth of the industry in the 75 years of AWWA. A full 100 of AWWA's Associate Members participated to make the exhibit the biggest show in water works history.

On the entertainment front it was Vance Lischer, Herb Hartung, Carl Buettner, and Gene Butler who headed up the committees in charge of keeping everybody happy. Starting with Sunday's Birthday Buffet, the events were all of sellout proportions. Thus, on Monday night, the president and his official family had more hands than ever to shake at the reception which followed the

1956 CONFERENCE STATISTICS

St. Louis Registration by Days

Day	Men	Ladies	Total
Sunday, May 6	976	287	1,263
Monday, May 7	792	212	1,004
Tuesday, May 8	143	11	154
Wednesday, May 9	80	–	80
Thursday, May 10	35	–	35
TOTALS	2,026	510	2,536

Geographic Distribution of Registrants

UNITED STATES & TERRITORIES

Alabama	39
Arizona	12
Arkansas	33
California	115
Colorado	30
Connecticut	25
Delaware	4
Dist. Columbia	19
Florida	31
Georgia	58
Hawaii	2
Illinois	308
Indiana	101
Iowa	75
Kansas	59
Kentucky	33
Louisiana	28
Maine	4
Maryland	24
Massachusetts	30
Michigan	64
Minnesota	34
Mississippi	16
Missouri	268
Montana	9
Nebraska	31
New Hampshire	3
New Jersey	106
New Mexico	2
New York	211
North Carolina	23
North Dakota	5
Ohio	140
Oklahoma	31
Oregon	6
Pennsylvania	206
Puerto Rico	1
Rhode Island	13
South Carolina	19
South Dakota	13
Tennessee	46
Texas	83
Utah	6
Virginia	29
Washington	18
West Virginia	16
Wisconsin	40
Wyoming	1

CANADA

Ontario	54
Quebec	1

FOREIGN

Asia	5
Europe	2
South America	4
TOTAL	2,536

Comparative Registration Totals—1947–1956

Year	Place	Men	Ladies	Total
1956	St. Louis	2,026	510	2,536
1955	Chicago	2,075	512	2,587
1954	Seattle	1,536	527	2,063
1953	Grand Rapids	1,532	365	1,897
1952	Kansas City	1,600	386	1,986
1951	Miami	1,415	491	1,906
1950	Philadelphia	1,678	329	2,007
1949	Chicago	1,593	374	1,967
1948	Atlantic City	1,348	356	1,704
1947	San Francisco	1,115	431	1,546

Win, Place & Show in Section Awards

Henshaw Cup		Hill Cup		Old Oaken Bucket	
Cuban	**72.2%**	**Southwest**	**28.67**	**California**	**1,266**
Montana	68.4%	Indiana	24.47	Southwest	994
Pacific Northwest	55.0%	California	19.98	New York	822

awarding of the year's honors. And on Tuesday, Rodgers and Hammerstein, an orchestra drawn from the St. Louis Symphony, and a chorus from the St. Louis Municipal Opera never had such an enthusiastic audience as the crowd that turned out to hear an evening of music from *Oklahoma, Allegro, South Pacific, Carousel,* and *The King and I.* With a golf tournament on Tuesday, and Wednesday night off for such excitement as major league baseball, the week was more than full of fun. It was Thursday's Anniversary Banquet and Ball, though, that really brought home the special birthday party nature of the conference. For the 1,100 who were able to crowd their way into the Gold Room of the Jefferson Hotel, the evening provided a real jubilee, featured, among other things, by the presentation of leis to the officers, past presidents, and other honored guests, the awarding of certificates of honor to the executives of 34 firms who have been Associate Members of AWWA for more than 50 years, the awarding of section prizes, and, finally, the inaugural speech of Paul Weir, incoming president.

In charge of bringing a second record crowd to the meeting and getting it home again was Transportation Committee Chairman Lou Frazza, and seeing that they were happy during their stay were committees that totaled in the hundreds, including not only Missourians but members from nearby Illinois communities. With Mrs. Vic Weir and Mrs. Tom Skinker leading the way, the ladies committees, too, worked harder than ever to see that the visiting distaff had the time of its life—and AWWA's. All of this effort and activity, of course, is the secret of the many happy returns of AWWA week.

Association Awards

Honorary Membership was conferred upon A. P. Black, Henry F. Cronin, Thomas J. Skinker, and W. Victor Weir. The citations follow:

ALVIN PERCY BLACK, Research Professor of Chemistry, University of Florida, Gainesville, Fla.: *member of the Association since 1929; President 1950; Director for the Florida Section 1936–39; recipient of the Fuller Award in 1939, the Goodell Prize in 1950, and the Diven Medal in 1955; a superlative teacher, one who inspires his students to their greatest efforts; a professional man who holds and defends his opinions firmly; a forward-thinking leader of our industry.*

HENRY FRANCIS CRONIN, Chief Engineer, Metropolitan Water Board, London, England: *member of the Association since 1944; in recognition of his many contributions to the water works profession, particularly for his outstanding leadership of the London Metropolitan Water Board with unfaltering courage and steadfast devotion to duty during the Blitz of World War II, and for his friendly spirit of cooperation with this Association.*

THOMAS JULIAN SKINKER, Commissioner of Water, St. Louis, Mo.: *member of the Association since 1924; Life Member since 1954; Director for the Missouri Section 1931–32; recipient of the Fuller Award in 1948; he has served the Association with distinction in all its divisions; a distinguished citizen of St. Louis; a great credit to a pioneer family which stands high in the traditions of the city; a devoted public servant in his community throughout his lifetime.*

WILLIAM VICTOR WEIR, President, St. Louis County Water Company, University City, Mo.: *member of the Association since 1924; President 1951; Director for the Missouri Section 1946–49; recipient of the Diven Medal in 1940, the Fuller Award in 1943, and the Goodell Prize in 1950; a highly capable engineer, a preeminent administrator; one who has devoted himself unsparingly to the advancement of the water works industry.*

The Harry E. Jordan Achievement Award, conferred when some member of the Association has distinguished himself outside the line of duty and in the form of a public service, was presented to WILLIAM JOHN ORCHARD, Director, Wallace & Tiernan Inc., Belleville N.J., *"for his boundless public spirit, manifested by his long record of unselfish services to the region in which he lives."*

The John M. Diven Medal, awarded to the member whose services to the water works field during the preceding year are deemed most outstanding, was presented to Fred G. Gordon. The citation follows:

FRED GUYON GORDON, Assistant Chief Engineer, Bureau of Engineering, Chicago, Ill.: *for his constructive leadership and accomplishments in the development, through a committee of which he was chairman, of standard specifications for metal-seated and rubber-seated butterfly valves—of great potential value in water works control and distribution—and for placing the engineering details of production of such valves on a sound and fully professional basis.*

The John M. Goodell Prize, granted for the best paper published in the JOURNAL from October 1954 through September 1955, was conferred jointly upon H. S. Swanson, H. J. Chapton, C. L. King, and E. D. Nelson. The citation follows:

H. S. SWANSON, H. J. CHAPTON, C. L. KING, and E. D. NELSON, respectively Structural Engineer Associate, Project Design Engineer, Structural Engineer Associate, and Civil Engineering Assistant of the Los Angeles Department of Water and Power (the fifth author, W. J. Wilkinson, is not a member of the Association): *for their paper, entitled "Design of Wye Branches for Steel Pipe," published in the June 1955 issue of the Journal* (Vol. 47, page 581). *Recognition is given to the authors' original and intensive research devoted to the wye branch problem; design of wye branches and wye branch fittings has been largely empirical in years past, and the data presented in this paper should contribute much to rational development in the future.*

Division Awards, granted for the best JOURNAL paper (October 1954–September 1955) in the field of interest of each of the four AWWA Divisions, were presented to Leslie Paul, Abel Wolman, Arnold K. Cherry, and Finley B. Laverty. The citations follow:

Distribution Division Award: LESLIE PAUL, Supervising Mechanical and Electrical Engineer, East Bay Municipal Utility District, Oakland, Calif.: *for his paper, entitled "Selection of Valves for Water Works Service." This paper, published in the November 1954 issue of the Journal* (Vol. 46, page 1057), *records the observations of a trained engineer critically applied to essential elements of water works service.*

Management Division Award: ABEL WOLMAN, Consulting Sanitary Engineer and Professor of Sanitary Engineering, Johns Hopkins University, Baltimore, Md.: *for his paper, entitled "Providing Reasonable Water Service." In this paper, published in the January 1955 issue of the Journal* (Vol. 47, page 1), *we find the mature judgment of one who has grown to world stature, applied to the real objectives of our industry.*

Purification Division Award: ARNOLD KENNETH CHERRY, Superintendent, Water Works, Cedar Rapids, Iowa: *for his paper, entitled "Split-Treatment Method of Water Softening." This paper, published in the April 1955 issue of the Journal* (Vol. 47, page 393), *records the diligence of a trained worker who has also demonstrated the ingenuity of a true inventor.*

Resources Division Award: FINLEY BURNAP LAVERTY, Consulting Engineer, Pasadena, Calif.: *for his paper, entitled "Development of a Fresh-Water Barrier in Southern California for the Prevention of Sea Water Intrusion." This paper, coauthored by Herbert A. van der Goot (nonmember) and published in the September 1955 issue of the Journal* (Vol. 47, page 886), *records the application of engineering skill to the recovery and future use of an important source of ground water supply.*

The Harry E. Jordan Scholarship Award, granted to further the education of a deserving applicant from the Far West (a different region is selected each year), was conferred upon MARVIN ROBERT LINDORF, a 1956 sanitary engineering graduate of the University of California.

The George Warren Fuller Awards were presented to 28 men whose Sections had nominated them in the year beginning with the 1955 Annual Conference at Chicago and ending with the opening of the 1956 Conference at St. Louis. The awards—which are conferred for "distinguished service in the water supply field and in commemoration of the sound engineering skill, the brilliant diplomatic talent, and the constructive leadership of men in the Association which characterized the life of George Warren Fuller"—went to the following men:

Alabama-Mississippi Section—CHARLES WILLIAM WHITE: *for his untiring efforts and devotion to the betterment of public water supplies in the state of Alabama; and for his unselfish labors as secretary-treasurer of the Alabama-Mississippi Section.*

Arizona Section—JOHN FRANCIS RAUSCHER: *in recognition of his constructive planning for the rapid expansion of the Tucson metropolitan area; his skillful organizing of operations and maintenance for the city of Tucson; and his promotion of sound water works practices while serving with the Army.*

California Section—JAMES STEWART PETERS: *for his constructive leadership in the solution of his community's difficult water service problems; his long record of helpful activities and interest in the California Section; his personal magnetism and enthusiasm for cooperation with and assistance to others.*

Canadian Section—WILLIAM LAWRENCE MCFAUL: *for his notable quality of leadership in the water works field; for his energetic development of a water works program for the rapidly growing city of Hamilton; and for his long and effective support of activities in the Canadian Section.*

Cuban Section—ERNESTO E. TRELLES Y DUELO: *for the harmony he has achieved within the membership of the Section, and in its relations with the government, the press, and the public; and for his organization and promotion of water works industry meetings, especially the Congreso de Acueductos Cubanos.*

Florida Section—CLIFFORD ELLIOT EARLS: *for his long-term devotion to the Section, not as an officer but as an ordinary member working for the good of the organization, especially as chairman of the membership and other committees, and for his unselfish aid to plant operators.*

Illinois Section—EDWARD EMMONS ALT: *for his outstanding service to the Illinois Section and its members; for his many contributions to the Association as a whole; and for his exemplary conduct as a manufacturers' representative.*

Indiana Section—HAROLD SIMMEON GRISWOLD: *for his unselfish sharing of technical know-how and never failing interest in water works men in his area; for his labors to establish or improve public water supplies; and for his contributions to the progress of the Indiana Section.*

Iowa Section—MARK EDGAR DRIFTMIER: *for his sustained interest and efforts over many years on behalf of the Association and the Section; and for the fact that the Burlington, Iowa, water works under his diligent supervision has advanced to high standing in the state.*

Kansas Section—ALBERT WALTON RUMSEY: *in recognition of his active participation and effective leadership in affairs of the Section; and for his faithful and competent service as chief chemist for the Board of Public Utilities of Kansas City.*

Kentucky-Tennessee Section—HENRY MARTIN GERBER: *for his tireless and constant promotion of good public relations; for his sound leadership in cordial*

labor relations; for his enviable record in safety attainments; and for his continuous interest in the Section and the Association.

Michigan Section—THEODORE LOUIS VANDER VELDE: *for his ever willing and never ending services to the Section, particularly as secretary-treasurer; and for his "beyond-the-line-of-duty" services to the state of Michigan in improving its standards of water treatment and purification.*

Missouri Section—FRANK EDWIN DOLSON: *for his high-level contributions to the activities of the Section; competent handling of committee assignments; tireless efforts in organization of the Distribution Division and services as chairman; and for the professional honors he has brought to the Missouri Section.*

Montana Section—KURT WIEL: *in recognition of his many years of service to the Montana Section and for his efficient and capable direction of his city's water supply.*

Nebraska Section—BERT GURNEY: *for his practice of putting service before self; his unstinting efforts in behalf of operators of small water works; and for his untiring interest in and contributions to the advancement of the Nebraska Section.*

New England Section—SIDNEY STEWART ANTHONY: *for his long-term active participation in the affairs of the Section, and for the help and encouragement he has given at meetings and on committees on the problems of the water works superintendent in New England.*

New Jersey Section—WALTER SPENCER (deceased): *in recognition of his long and failthful service to the water works profession, to the New Jersey Section, and to his community.*

New York Section—WILLIAM WHITLOCK BRUSH: *devoted and outstanding leader; President of the Association in 1929; Treasurer for more than thirty years; distinguished editor and contributor to the literature of our industry; his constant aim has been to raise the standards and maintain the high ethics of the water works profession.*

North Carolina Section—EDWARD ROUNTREE TULL: *for his constant devotion to the advancement of the Section; his numerous and constructive committee activities for the Section and the operators' group; and for his sincere, honest, and efficient community service as administrator of the Rockingham Water Department.*

North Central Section—WILLIAM YEGEN: *for his long and enthusiastic service in behalf of the Association and Section, as indicated by his work on many committees and his continued deep interest and efforts in membership promotion.*

Ohio Section—JOHN STEELE GETTRUST: *for his contributions to the early activities in water treatment practice in Ohio; for his sustained interest in the Association; and for his outstanding service of more than forty years in charge of water purification at Akron.*

Pacific Northwest Section—ALFRED HARRY LABSAP: *in tribute to his accomplishments in the management and engineering of a rapidly expanding water works system; and for his contributions to the advancement of the Section and the Association.*

Pennsylvania Section—LAWSON DEACON MATTER: *in recognition of his outstanding service to the Section; and for his many years of faithful public health engineering activities devoted mainly to the improvement of water supplies.*

Southeastern Section—ROBERT CLASS KAUFFMAN: *in recognition of his many contributions to the Southeastern Section; his outstanding achievements as a consulting engineer for more than twenty years; and his tireless efforts in raising the standards of the water works profession.*

Southwest Section—LONNIE COTHRAN ELDRIDGE: *in recognition of many years of distinguished service in engineering and administration of a large water supply system; support of educational programs; and generous help to fellow workers.*

Virginia Section—WILLIAM BOYS HARMAN: *in recognition of his intelligent management of the Newport News Water Works Commission; his unselfish and highly competent services to the Section; and for his constant devotion to the service of his community.*

West Virginia Section—HENRY WITHERS SPEIDEN: *in recognition of his valuable services to the Section, most recently as National Director, and his active participation in the development and progress of good water works practice, particularly through the operation of the short school for operators at West Virginia University.*

Wisconsin Section—HENRY ERNEST SKIBBE: *for his devoted and untiring efforts toward increasing the membership and promoting attendance at the annual meetings of the Section, as well as his many contributions to the general welfare of the Association.*

Schedule of Conference Papers and Reports

Open Session—Water Works Administration Committee—9:30 AM—Monday, May 7

Task Group Reports
- NARUC Rules and Regulations....John H. Murdoch Jr.
- Rules and Regulations of the California Commission....W. C. Welmon
- Job Classification....Robert S. Millar
- Rating Water Systems....John H. Murdoch Jr.

Survey of Mobile Radio Use, 1955....M. B. Cunningham

Purification Division—9:30 AM—Monday, May 7

Calcite Stabilization of Lime-softened Water....H. O. Hartung
- Discussion....V. J. Calise

Panel Discussion—Water Treatment Section, State Sanitary Engineers' Manual—Plans for Public Water Supplies....*Led by* Philip Morgan, W. W. Aultman, E. H. Aldrich & C. W. Klassen

Purification Division—2:00 PM—Monday, May 7

New Algicides....................C. M. Palmer
Economics of Sludge Removal....................Fred G. Gordon
Coliform Limits for Raw Waters....................Graham Walton
Diatomite Versus Conventional Filter Performance....................G. R. Bell

Joint Session—Resources and Management Divisions—2:00 PM—Monday, May 7

Panel Discussion—St. Louis Area Water Supply Developments.........*Led by* C. M. Roos
Water Resources of the Area....................C. M. Roos
Water Resources Development on the East Side of the Mississippi River.....S. C. Casteel
Water Resources Development for the City of St. Louis....................John B. Dean
Water Resources Development in St. Louis County....................W. V. Weir
Water Quality and Treatment Requirements....................W. B. Schworm
Shall Recreational Uses of Water Works Impounding Reservoirs Be Permitted?..........
Robert B. Diemer, Merrill L. Riehl & Alexander Minkus

Joint Session—Management and Resources Divisions—9:30 AM—Tuesday, May 8

The Status of Federal Highway Legislation....................Harry E. Jordan
The Nation's Water Resources....................Fred G. Aandahl
Panel Discussion—The Missouri River....................*Led by* John W. Cramer
Effect Upon the Total River Flow of Present and Probable Future Operation of Main-Stem Dams....................Wendell E. Johnson
Recent Changes and Trends in Quantity and Quality of Missouri River Water and of Ground Water in the Immediate Vicinity of the River.............George E. Ferguson
Present Conditions and Trends in the Pollution of the River..........Dwight F. Metzler
Experiences and Observations of the Water Utility Executive....................
John C. Detweiler & James B. Ramsey

Open Session—Water Works Practice Committee—2:00 PM—Tuesday, May 8

Committee Progress Report—Meter Standards....................James G. Carns
Research Committee Reports
Effect of Water Treatment Methods on Water Main Carrying Capacity......T. E. Larson
Toxicity Studies on Cadmium and Chromium in Public Water Supplies......C. F. Decker
General Policy Committee Report on Conformance to Standards.........M. B. Cunningham

Resources Division—2:00 PM—Tuesday, May 8

Water Demand Potential of Irrigation in Humid Areas....................John R. Davis
The Evaluation of Weather Modification Experiments....................F. A. Berry
Evaluation of Water Resources Section, State Sanitary Engineers' Manual—Task Group Report....................Louis J. Alexander & Samuel B. Nelson
Discussion....................B. A. Poole

Distribution Division—9:30 AM—Wednesday, May 9

Control of Booster Stations to Serve Areas Requiring Secondary Pumping..Marvin H. Owen
Centralized Load Dispatching Experience.................J. M. Jester & J. W. Henderson
Problems in Purchase of Water—Demand or Penalty Rates....................V. C. Lischer
Surge Control on Transmission Lines of the St. Louis County Water Company..F. E. Dolson

Management Division—9:30 AM—Wednesday, May 9

Management Reorganization of Philadelphia Water Department..........Samuel S. Baxter
Modernizing the Metering Program of the Philadelphia Water Department...............
Gerald E. Arnold
How Meters Affect Revenue..Wentworth Smith

Management Division—2:30 PM—Wednesday, May 9

Water Works Management Section of State Sanitary Engineers' Manual..................
Paul D. Haney, M. P. Hatcher & Dwight F. Metzler

Distribution Division—2:30 PM—Wednesday, May 9

Water Distribution Section of State Sanitary Engineers' Manual..........................
Russell G. Kincaid, L. S. Finch & Earl Devendorf

General Session—10:00 AM—Thursday, May 10

Seventy-Five Years' Improvement in Water Supply Quality.................Abel Wolman
Seventy-Five Years of Progress in Materials and Construction..........E. Sherman Chase
Seventy-Five Years of Too Cheap Water...........................John H. Murdoch Jr.

Distribution Division—9:30 AM—Thursday, May 10

Behavior of Steel Pipe Under Earth Loads...............................R. E. Barnard
Soil Mechanics and Trenching Practices.....................................Henry Reitz
External-Corrosion Problems in the Water Distribution System...........L. P. Sudrabin

Management Division—2:00 PM—Thursday, May 10

Service Requirements of Water-connected Devices........................James G. Carns
Galvanic Corrosion in Water Meters.......................................H. F. Barrett
Studies in Water Use.................................Ross Hanson & H. E. Hudson Jr.
The In-Service Training Program of the Philadelphia Suburban Water Company..........
Kenneth E. Shull & George H. Dann

Papers Scheduled at 1956 Section Meetings

THERE follows a summary listing of papers scheduled for presentation at 1956 Section Meetings. The dates of the Section Meetings from 1952 to 1956 and the locations for 1956 are listed on page 1582. Section officers who were elected at meetings held during 1956 are listed on page 2 P&R in the front of this issue. The programs are listed alphabetically by Sections, without regard to the date of presentation.

Alabama-Mississippi Section—October 21–24, 1956

Address of Welcome..*Mayor* Henry R. Luscher
Records and Accounting for Small Systems........................Jess L. Haley
Responsibility of Health Department to Water Works Operators..........A. N. Beck
Problems in Stream Pollution..............................Martin E. Flentje
What's Wrong With the Municipal Utility Business................W. E. Hooper
Fire Protection Requirements...................................R. H. Tucker
Pump Application and Maintenance................................John L. Snow
Basic Hydraulics..R. J. Sweitzer
Specifications for Cast-Iron Pipe.........................Wallace T. Miller
Proper Sizing of Water Meters.............................Charlie Matthews
Panel—Water Rates....................................*Led by* E. Clinton Smith
Domestic Rates..Richard H. Cobbs
Industrial Rates..Frank Crow
Fire Protection Rates..Tip Allen
Rates Brought up to Date..................................W. P. Gearhiser
Application of Glassy Phosphates in Municipal Water Systems..........George Illig

Arizona Section—April 5–7, 1956

Address of Welcome..*Mayor* O. O. Rawson
Response...G. Ted Rekerdre
New Developments in Water Pipe Joints..........Gene R. McVety & George J. Bogs
Controls and Instrumentation..............................Paul V. Hennessy
Fire Protection for Small Water Systems...................Harry C. Bigglestone
Modern Comforts and Their Effect on Water Use....................Dario Travaini
Pipe Laying and Pressure Controls in Hilly Areas..................E. S. Mamrelli
Tank and Pipeline Corrosion...................................Jack McNary
Cathodic Protection for Pipelines and Tanks......................Frank Buck
Sewage Disposal Systems for Small Communities...................T. L. Herrick
Panel Discussion—Excavation and Backfill
Recommended Practices for Concrete Pipe...............John G. Hendrickson Jr.
Recommended Practices for Asbestos Pipe.......................A. W. Miller
Recommended Practices for Cast-Iron Pipe....................Glade Anderson
Engineers' Viewpoint..H. W. Yost
Contractors' Viewpoint.....................................Phil Hunziker
Industry Developments and a Look Into the Future—A Demonstration..Orville L. Dickinson
Hypochlorinators—A Demonstration...............................A. L. Frick Jr.
Operators' Roundup..................................*Led by* E. O. Dye, Roy Hilbrant & R. E. Polenske
Short-School Training of Operators...........................R. J. Umbenhauer

California Section—Regional Meeting—April 13, 1956

Address of Welcome.......................................*Mayor* Gordon G. Dunn
Response...W. R. Seeger
Engineering and Operational Problems of Small Utilities..................T. C. Binkley
Problems of Water Supply During California's Recent Floods................L. A. Beck
Make Them *Read* Your Annual Report..........................Samuel L. Friedman
Panel Discussion...*Led by* J. D. DeCosta
  Service and Distribution Problems................................John N. Spaulding
  Distribution Storage...J. W. Trahern
  Management Problems..George W. Pracy
  Construction and Maintenance Problems—Pipelines........................A. V. Lynn
  Legal Rights and Responsibilities of Water Departments—Privately and Publicly Owned.. Rex B. Goodcell Jr.

California Section—October 23–26, 1956

Address of Welcome.......................................*Mayor* Charles C. Dail
San Diego County and Water...Paul Beermann
How Much for Your Water Rights?................................James H. Krieger
Construction and Public Relations......................................G. W. Jones
Water Quality—Changing Concept in California..........................J. E. McKee
California Is Listening..Samuel B. Morris
Program of the Department of Water Resources......................Harvey O. Banks
Program of the State Water Rights Board.........................Henry Holsinger
Where Should Local Water Authorities Take the Initiative?.............J. W. McFarland
Local Authorities' Part in the California Water Plan......................William Berry
Water Problems for the Legislature...................................Harold J. Powers
Financing Both Large and Small Units of the Water Plan.................Bruce F. Allen
Flood Control Problems and Their Solution.......................William F. Cassidy
Federal Service and the California Water Plan...........................Clyde Spencer
Legal Questions Which Must Be Answered...........................Wallace Howland
Conversion of Water Systems From Irrigation to Dual-Purpose Irrigation and Domestic Systems...L. R. Burzell
Underground Pump Installations......................................D. S. Kingman
Plastics in Water Use—1956...............Harold Yackey, John Spaulding & Max Socha
Engineers in Short Supply...N. J. Kendall
General Management Problems and What We Have Done About Them....Peter A. Nenzel
Contributions—Accounting and Financial Phases.........................John Donovan
Rate Base Considerations..C. Unnevehr
Economic Outlook for the Next Ten Years.......................George H. Hildebrand
Fish Eradication in San Diego Reservoirs..........................Roy E. Dodson Jr.
Automatic Chlorination Control by Continuous Remote Residual Determination............ William Bruce Murray
Application of Microbiological Techniques...........................Donald G. Larkin
Removal of Radioactive Contamination From Drinking Water.........Warren J. Kaufman
A Research Approach to Water Planning...............................Neil T. Houston

Canadian Section—April 23–25, 1956

Address of Welcome..*Mayor* Ray Dennis
Response...F. C. Amsbary Jr.
Effects of pH and Velocity on Corrosion of Steel Water Pipes........................ Rolf Eliassen & Rolf T. Skrinde
Fluoridation of Water Supplies
  Selection of Equipment...J. D. Reid
  Tests and Dosage Control..G. M. Galimberti
  Discussion...D. B. Williams
Ground Temperatures Near Water and Sewer Lines at Yellowknife, N.W.T............. S. C. Copp, J. W. Grainge & C. B. Crawford

Developments in the Design of Water Purification Plants .... G. E. M. Proctor & R. G. Tredgett
Water Works in Civil Defense .... F. C. Pace & J. R. Menzies
London's Water Supply—Past, Present, and Future .... B. W. Grover
Water Works Courses and Certification .... G. H. Strickland
Water Resources for Ontario .... A. M. Snider
Selection of Water Works Pumping Equipment .... W. K. Clawson

Canadian Section—Maritime Branch—October 15–16, 1956

Bathurst Reservoir Project .... M. H. Rogers
Problems in Water Works Systems—Panel Discussion .... *Led by* A. V. McQuarrie
Gagetown's Water and Sewer System .... K. J. Chisholm
Discussion .... W. B. Akerley
Administration and Office Procedures—Panel Discussion .... *Led by* Harold Sewell
Safety in Water Works .... R. J. Faust & R. C. Patterson

Chesapeake Section—October 24–26, 1956

Address of Welcome .... George A. Carter
Radiation Monitoring .... Harry M. Lowe Jr.
Discussion .... John W. Krasauskas
Water Resources Problems: Facing the Facts
Maryland .... Joseph T. Singewald Jr.
Delaware .... John T. Groot
Effect of Power Plant Waste Cooling on Municipal Supplies .... Charles E. Renn
Civil Defense in the Baltimore Area up to Now .... Frank Milani
Forecasting Water Requirements for Distribution Systems
Domestic .... George B. Wolff
Industrial .... Joseph W. Wills
Property Cost Trends by Index Numbers .... E. C. North
Water Practices in South America .... John C. Geyer
Fluorspar for Fluoridation .... F. J. Maier
Discussion .... Gill Montgomery & David Wood
Centralized Load-dispatching Experiences .... John M. Jester
Choice of Valves for Special Purposes .... *Led by* Fred E. Stuart
Gate Valves .... Henry A. Perkerson
Plug Valves .... Walter Hamill
Butterfly Valves .... Henry C. Schwenk
Sluice Gates .... John H. Sheehan
Films
People, Products, and Progress
Melting Snows to You

Cuban Section—November 29–December 1, 1956

Program not available.

Florida Section—November 11–14, 1956

Address of Welcome .... *Mayor* Francis W. Morrison
Water Works Industry Becomes of Age .... Harry E. Jordan
National Water Resources Policy .... Mark Hollis
Florida Water Resources Policy .... David B. Smith
The Man Who Reads Your Water Meters .... Curtis H. Stanton
Water Purity and the Tourist Trade .... Laurence Daniel
Florida State Road Department Policy on Utility Relocations .... Earl P. Powers
American Water Works Association Policy on Utility Relocations .... Harry E. Jordan
Anaerobic Treatment of Industrial Wastes .... Arthur M. Buswell
Industrial Development of Florida .... B. R. Fuller Jr.

Liquid-Wastes Control in Phosphate Processing Plant
Triple Superphosphorus....R. E. Tuttle
Phosphorus and Superphosphate....Randolph Specht
Panel Discussion—Recent Developments in Industrial-Wastes Treatment....
Led by J. W. Wakefield
Ten Years of Water and Sewerage Development in Florida....David B. Lee
Panel Discussion—Water Supply Problems of Growth and Expansion....
Led by Don W. Jones,
Allen Henry, John Kelly, Garrett Sloan & Nathan B. Rood
Specialty Board Certification for Sanitary Engineers....John E. Kiker
Waste Treatment in the Atomic Age....Kenneth S. Watson
Water Treatment Plant Sludge Disposal....A. P. Black
NBFU Influence on Design of Water Supply Systems....O. G. Carpenter
Films
Deep Waters
Water—Wealth or Worry for America
Pipeline to the Clouds
From the Mountains to the Sea
Taken for Granted

Illinois Section—March 21–23, 1956

Address of Welcome....James W. Jardine
Instrumentation in Water Plants....R. R. Scott
Automatic Control in Water Plants....M. E. Rodgers
Panel Discussion—Water Shortages and Remedies
Causes....W. J. Roberts
Supplementary Emergency Supplies....William J. Downer
Conservation....J. B. Stall
Storage on Distribution Systems....John A. Fulkman
Valves....J. H. Whisler
Interesting Features of New Filtration and Purification Plant Design at St. Louis County Water Company....H. O. Hartung
The Use of Activated Silica in Water Plant Operation....Orville Smith
Discussion....Robert J. Baker
Aids to Coagulation....R. W. Kirconnell
Public Speaking....L. W. Olson
Water Rates for Air Conditioning....Michael Zihal
Water Rates....Louis R. Howson
Clean Streams....Lewis I. Birdsall
Discussion....C. W. Klassen
On-the-Job Training....H. S. Hall
Latest Developments in Protection Against Plumbing Hazards....Edward Zimmer
The Role That Mobile Two-Way Radio Plays in Water Department Operation..Eric Goleas
Legal Aspects of Water Works Operations....M. S. Rembe
Cathodic Protection....James Meeker
Swimming Pool Operation....Elmo Conrady & W. M. Honsa

Indiana Section—February 8–10, 1956

Address of Welcome....George G. Fassnacht
Reducing Unaccounted-for Water by Continuous Leak Survey....Howard Niemeyer
Water Works Operation During Major Disaster....F. P. Stradling
New Chemicals for Water Treatment....Leo Louis
Algae and Other Interference Organisms in Indiana Water Supplies....
C. Mervin Palmer & H. W. Poston
Some Applications of Geophysics to Explorations for Ground Water....Maurice E. Biggs
Various Types of Pumping Tests Available and Their Application to Ground Water Problems....Frank A. Watkins
Use of Instruments and Pumping Tests on Indiana Projects....William G. Keck
Panel Discussion—Is There Enough Water for Everyone?....*Led by* L. S. Finch
National Aspects of Water Resources Problems....Paul Weir

Water Use Law....John H. Murdoch Jr.
Indiana Water Resources Study Commission....Anson Thomas
The Importance of Water in Meeting Public Water Supply and Sewage Disposal Needs... B. A. Poole
Aspects of Irrigation in Indiana....Donald R. Sisson
Flood Control and Water Resources....Robert Kellum

Iowa Section—October 24–26, 1956

Address of Welcome....*Mayor* Ray Mills
Response....D. L. Bragg
Diatomite Filters for Municipalities....E. R. Baumann
Programing for Maximum Well Pump Economy....Harris F. Seidel
Why Plastics With Water?....G. A. Stein
Demineralization of Saline Waters....Karl Kammermeyer
Drinking Water From Farm Ponds....Eric B. Fowler
Purchasing Water Works Insurance....Howard J. McGuff
General Aspects of Engineering Study at Sioux City, Iowa....Jim Sampson
Certification of Water Works Operators....W. H. Downer
Discussion....H. S. Smith
Water Works Financing....R. J. Allender
Water Laws in Iowa....Eugene Davis
Recommendations of the Iowa Water and Drainage Law Study Committee.... Wendell Pendleton
Panel Discussion—Distribution and Management Problems....*Led by* D. Y. Caldwell
Panel Discussion—Treatment Problems....*Led by* M. L. Powell

Kansas Section—April 4–6, 1956

Address of Welcome....*Mayor* George G. Schnellbacher
Response....G. Dorr Pelton
The Value of Hydraulic Measurements on the Distribution System....C. N. Clanton
Current Water Works Specifications for Cast-Iron Pipe....Paul Green
Types of Chlorinators and Their Maintenance....Joseph Gyulay
Taste and Odor Control....Joseph G. Filicky
Panel Discussion—Maintenance of Fire Hydrants....*Led by* Orville G. Kuran, Roy F. Bluejacket, Alar B. Mawdsley, Fred D. Diehl & Harold R. Volkmann
Federal Legislation Affecting Public Utilities in Highway Construction....Harry E. Jordan
Industrial Reuse of Water....Ralph E. Fuhrman
Pumps and Pump Maintenance....
Atomic Power and the Water We Drink....Russell L. Culp
Rainmaking....
Establishing Utility Rates and Service Charges....W. B. Avery
Industrial-Waste Problems at Boeing Plant in Wichita....Robert E. Cranford
Effects of Severe Droughts on Kansas Water Supplies and What Action Should Be Taken by the State Board of Health....Dwight F. Metzler
Cathodic Protection....R. H. McLeod Jr.
Panel Discussion—Taste and Odor....*Led by* Albert W. Rumsey, Frank E. Willey, Robert J. Mounsey & H. H. Kansteiner
Water Meter Testing and Equipment....John L. Ford & David Ford
Water Meter Maintenance Procedures....Frank E. Dolson
Panel Discussion—Municipal Water Well Construction and Maintenance.... *Led by* Ray E. Lawrence, Darwin R. Soder & E. N. Jungmann

Kentucky-Tennessee Section—September 17–19, 1956

Address of Welcome....*Mayor* P. R. Olgiati
Response....Elmer Smith
States' Position in Setting Stream Standards....David B. Lee
Report of Tennessee Water Resources Committee....Jim McCord

Water and Growth..Lewis Young
Radioactive Sediments in the Tennessee River System..J. M. Garner Jr. & O. W. Kochtitzky
Safety in Water Utilities..Raymond J. Faust
Safety Program—Panel Discussion..............................*Led by* Robert Fischer
Setting up a Safety Program...M. B. Whitaker
Application of Safety Program in Distribution System.....................W. S. Cifers
Application of Safety Program in Pumping and Filtration Plant.........Earl T. Mitchell
Application of Safety Program in Office Personnel......................Henry Gerber
Customer Complaints—Panel Discussion..........................*Led by* E. E. Jacobson
Red Water...John Burka
High Bill..Starling S. Gregory
Noise in Pipes...W. E. Hobbs
Weak Pressure..Perry Therrell
Development of Water Districts....................................Campbell Wallace
Operating and Managing of Water Districts...........................Frank S. Rast Jr.
Principal Types of Protective Coatings..............................LeRoy E. Sturgis
Films
Constructing a Four-Million-Gallon Reservoir
Mobile Radio

Michigan Section—September 12–14, 1956

Address of Welcome...*Mayor* Glenn S. Allen
News From the Field...John E. Vogt
Kalamazoo's Water Supply..Al Sabo
Air-Conditioning Regulation.......................................Tom B. Robinson
The Effect of Sprinkling Restrictions...............................Melbourne Stewart
Design and Rating of Wells and Well Fields...............................Lynn Miller
Maintenance and Operation of Wells
Drift Wells...Paul Sabo
Rock Wells...Claud R. Erickson
Flocculation and Flocculation Aids.............................Herbert E. Hudson Jr.
Actinomycetes and Their Relation to Taste and Odor in Water Supply...................
G. M. Ridenour & E. H. Armbruster
The Control of Tastes and Odors Due to Algae, Phenols, and Other Chemical Wastes....
George Hazey, Robert Haw, Louis B. Harrison & Garnet H. Campell
Alkalinity Correlations..John F. Dye
Water Pollution Problems in Wyoming Township.......................A. Edward Ward
The Need for Water Projects and How to Finance Them..............................
Louis E. Ayres, Stratton S. Brown, Donald C. Egbert, John D. Harrison & John E. Vogt
Investigation and Treatment of Water Quality Complaints.............................
William Wallace & Albert M. Shannon
AWWA Specifications..Raymond J. Faust
Area Planning for Water Needs......................................George Schmid

Missouri Section—September 30–October 2, 1956

Address of Welcome...Arthur Ellis
Water, the Great Catalyst...Fred Merryfield
The Effects of Missouri River Pollution on Community Water Supply—Panel Discussion...
Led by Herbert O. Hartung,
R. Bishop, W. Oelklaus, W. Helmreich, J. L. Teupker & W. B. Schworm
Recent Developments in Water Pollution Control............................Glen Hopkins
Safety Practices in the Water Works Industry..................................O. G. Kuran
Increasing Revenue Without Raising Rates..............................Raymond Bishop
Water and Sewage Administration......................................William S. Foster
Plant Supervision..Jesse Barlow
Customer Accounting and Commercial Office Procedures—Panel Discussion..............
Led by Frank McAndrew
Service to Customers...Raymond Piner
Billing Procedures..Wayne Kuehl

Accounting Procedures....Fred Williams
Incidental Procedures....George Ferrell
Pump Maintenance—Panel Discussion....R. C. Glazebrook
Ground Water Resources in the State of Missouri....L. M. Heckman
Film—Made to Measure

Montana Section—April 6–7, 1956

Address of Welcome....*Mayor* Walter Anderson
Microstraining....George R. Evans
Public Employees' Retirement and Social Security....John Sasek
Round Table Discussion....Ben Chestnut
Why Retain a Consulting Engineer?....Fred Merryfield
Public Relations....A. O. Putnam

Nebraska Section—April 11–13, 1956

Address of Welcome....*Mayor* Clark Jeary
Response....E. Bruce Meier
Nebraska State Laws Affecting Municipal-Utilities Operations....Tom Davies
Two-Way Radio Communication for Our Utilities....Paul Feistner
Panel Discussion—Economical and Practical Sizing of Water Mains and Pumping Discharge....*Led by* John W. Cramer
Fire Flow Requirements—What They Are and Why....E. C. Wagner
Economics of Pipe Size Versus Pumping Cost....Joseph Rossbach
Selling the Governing Body on the Need for Adequate Pipe Sizes....Harry L. Morris
Quick Graphical Comparison of Pipe Sizes for Given Flow Requirements....John W. Cramer
Report of Conferences and Schools....W. E. Minford
Putting Public Relations to Work....Harold E. Rolls
Benefits of Distribution Feeder Voltage Regulators and Capacitors....R. D. Okerberg
Trends in Residential Metering....Fred E. Briggs
Explanation of Services Available Through AWWA Membership....Jere Ott
Lincoln's Water Expansion Program....D. L. Erickson
Radio and Television Interference Problems....Charles Rook
Nebraska Water Legislation and Associated Administrative Problems....Dan S. Jones

New Jersey Section—October 18–20, 1956

Membrane Filter Technique as Used in the Bacteriological Examination of Water....Charles E. Renn
Coliform Removal Efficiencies as Measured by MF and MPN Procedures....Peter E. Pallo
Maintaining Pipeline Coefficients After Cleaning....William Monie
Civil Defense and Disaster Control....Jacob T. Lewis
Water Works Disaster Control Planning in Lancaster County, Pa....Leon S. Duckworth
Iron Removal Problems and Experiences....John T. Kearns, John J. Hamilton & Martin E. Flentje
Reservoir and Purification Plant Improvement Program, Commonwealth Water Co.
Engineering Aspects....George Paul
Commonwealth Water Company....George Paul
Design of Facilities....Howard Carlock
Panel Discussion—Hydrants, Meters, and Pipeline Cleaning....*Led by* Oscar Newquist
Films
Mobile Radio Communication Equipment
Manufacture of Prestressed Concrete Embedded Cylinder Pipe
Construction of the Georges Bank Reservoir Section

New York Section—April 18–20, 1956

Panel Discussion—Metering....*Led by* George E. Symons
Relation of Service Sizes to Meters....Charles W. Krause
Public Relations Problems of Metering....Joseph S. Rosapepe
Meter Maintenance Practices at Utica, N.Y....John P. Schmidt

Newly Constructed Utica Board of Water Supply Service Building.......Frank Della Cese
Economic Inspection of Cast-Iron Pipe..................................A. F. Maxfield
How to Purchase Cast-Iron Pipe Using ASA Specifications.............James C. Harding
Round Table Conference..*Led by* Angus D. Henderson
Ultrasonic Cleaning of Water Meter Parts................................George Lobb

New York Section—September 12–14, 1956

Panel Discussion—Main Extensions...........................*Led by* George E. Symons
Fundamental Concepts and Policies...............................William T. Ingram
Modern Practices...John G. Copley
Automation and the Automatic Valve...............................William F. End Jr.
Panel Discussion—Valves.....................................*Led by* Frank C. Amsbary Jr.
How to Use Your AWWA Specifications for Valves..................Harry E. Jordan
Gate Valves...LeRoy J. Evans
Butterfly Valves...D. W. Hopkins
Cone Valves...Gordon Holdridge
Round Table Conference.......................................*Led by* Angus D. Henderson

North Carolina Section—November 12–14, 1956

Address of Welcome...*Mayor* Philip S. Van Every
Water and Sewerage Facilities of Charlotte—Past, Present, and Future.................. Walter M. Franklin
Protective Treatment for Steel Tank Interiors and Other Steel and Iron Equipment....... T. V. Altizer
Use of Water Under North Carolina Statutes...........................Claude L. Love
Treatment of Fringe Areas as Regards Utilities.........................George H. Esser
Federal Aid for Pollution Abatement...................................E. C. Hubbard
Panel Discussion—Operators' Problems...........................*Led by* J. M. Jarrett
Recruitment, Training, and Classification of Water and Sewer Plant Operators........... J. L. Greenlee
Smaller-Town Operating Problems.......................................F. R. Blaisdell
Training of Personnel and Safety ....A. E. McCauley
Filtration and Iron Removal in Smaller Systems—Panel Discussion...*Led by* W. Banister, L. Rogers, O. Kuehne & E. Rosef
Automatic Control and Operation of Pumping Stations....................J. S. Williams

North Central Section—September 12–14, 1956

Our Diminishing Water Supply—Panel Discussion
Geology...Robert Schneider
Ground Water..R. K. Bergerson
Well Construction...H. S. Grove
Maintenance of Wells...Earl Smith
Electrolytic or Cathodic Protection of Steel Water Tanks..............Harold Ludeker
General Question and Answer Period..........................*Led by* Marinus Jensen, Clarence H. Nelson, L. H. Coult & William Yegen
Water Rate Revisions..A. P. Learned
Rapid Filters and Their Maintenance—Panel Discussion.............*Led by* C. M. Bach

Ohio Section—September 19–21, 1956

Address of Welcome..*Mayor* Ollie Czelusta
Public Relations..S. J. Wittenberg
Springfield Water Works Progress Report...............................Robert Holt
Water Supply From Upland Storage.....................................L. G. Williams
A Suburban Water Supply..Harlan Mace
Cleveland Water Works Improvements.............................Frank J. Schwemler
General Discussion of Operating Problems.....................*Led by* M. W. Tatlock
Industrial Water Uses..R. F. Snyder

Water Supply for Large Industries..R. C. Lewis
Advantage of Monthly Billing..A. V. Agnew
Water Works Expansion Program..R. R. Deem
The New Water Works..Harold Augenstein
Taste and Odor Control of Ohio River Water..Donald T. Duke
Experimental Results—Precipitation Rate of Calcium..G. F. Swanger
High-Rate Lime Softening..Carl L. West
Precast Concrete for Filter Underdrains..Kenneth W. Cosens
The Toledo Water Works..Carlton S. Finkbeiner
Purification Plant Operation in Toledo..R. R. Henderson

Pacific Northwest Section—April 26–28, 1956

Address of Welcome..*Mayor* Percy Scurrah
Panel Discussion—Methods, Equipment, Materials, and Procedures for Efficient Shop and Field Work....................Ben O. Nelson, Tom M. Smith & Russell Winchcomb
Panel Discussion—Stream Diversion, Intake, and Crossing Problems, Including Fisheries' Requirements............H. Kenneth Anderson, Robert L. Brunton, Charles H. Clay & Harlan B. Holmes
Panel Discussion—Administrative, Operational, and Financial Matters, Highway and Water System Reconstruction........William P. Hughes, Russell Lomax, George A. Marshall & Richard Thorgrimson
Distribution Reservoirs—Design and Construction
Steel Reservoir, Spokane, Wash..Glen A. Yake
Prestressed Concrete Reservoirs..Holly A. Cornell
Concrete, Ellipsoidal Dome Reservoir..James D. Caufield
Panel Discussion—Reservoir Maintenance and Operation..
Allen H. Boyer, Lloyd Hebert, Alwin Koch & Paul Meyer
Panel Discussion—Force Account Versus Contract Construction..
Robert A. Duff, W. C. Fry, Harold Kaeser & J. A. Kuehl

Pennsylvania Section—April 3–5, 1956

Development and Use of the Pipeline Network Analyzer by the City of Philadelphia.......
Victor A. Appleyard
Automatic Coagulation Control....................R. H. Babcock & Kenneth F. Knowlton
Panel Discussion—Training of Water Works Personnel............*Led by* Francis S. Friel
AWWA Short-Course Procedure..Raymond J. Faust
The In-Service Training Program of the Philadelphia Suburban Water Company........
George H. Dann & Kenneth Shull
Proposed Water Works Training Program in Pennsylvania................L. D. Matter
Training in Public Relations..Robert Coates
Water Works Problems Caused by Hurricane Diane
The Pennsylvania Health Department Aspect..Bernard S. Bush
In the Lackawanna Valley..Rulison Evans
In the Pocono Region..Marshall Reese
Friction Losses in Service Lines and Fittings..G. E. Arnold
Discussion..James G. Carns Jr.
Let's Plan Now for Water Supply Requirements of the Year 2000..........James H. Allen
Financing Pipeline Extensions in Suburban Areas...................John H. Murdoch Jr.
The Development of New Facilities in the Water Works Field..
Marsden C. Smith, Martin E. Flentje & Everett M. Jones

Rocky Mountain Section—November 26–28, 1956

Address of Welcome..*Mayor* Harry Blunt
Response..J. Orville Jones
Development of Water from the Western Slope for the City of Denver........E. L. Mosley
Reservoir Operation..Thomas J. Eaton
Ground Water in New Mexico..Clyde S. Conover
Ground Water in Colorado..P. T. Voegeli

Ground Water in Wyoming	H. M. Babcock
Hydraulics of Long Supply Lines	R. E. Barnard
Protective Coatings, Long Supply Lines	Robert J. Lyman
Water Consumption and Costs—Panel Discussion	*Led by* Orville Jones
Colorado	William N. Gahr
New Mexico	Charles G. Caldwell
Water Revenue Bonds	Elmer G. Longwell
Revised Federal Specifications for Cast-Iron Pipe	T. L. Johnson
Microstraining	G. R. Evans

Southeastern Section—March 18–21, 1956

Address of Welcome	*Mayor* Hugh L. Hamilton
Water Works, Pacesetter of Progress	Paul Weir
Weather Modification in Theory and Practice	Irving P. Krick
Discussion	W. H. Weir
Panel Discussion—Water Distribution Systems	*Led by* John R. Bettis
Excavation and Backfilling in Water Pipe Trenches	George F. Sowers
Choice of Pipeline Materials	Robert C. Kauffman
Some Practical Aspects of Laying Pipe	Roy Ruggles
Flow Analysis of Distribution Systems Containing Elevated Reservoirs	Alison T. Adams
The Golden Strip Water District—Panel Discussion	*Led by* Carl C. Lanford
Development and Design	E. E. Bolls Jr.
Source of Supply	John R. Hawkins
The Ultimate User	James C. Cousins
Taste and Odor Control	J. K. G. Silvey
Responsibilities and Limitations of Public Water Supplies in Meeting Industrial Requirements	John R. Bettis
Safety Practices in Water Works	Raymond J. Faust
Casualty Insurance for Water Works	E. J. Gallagher
Discussion	Oscar M. Fuller

Southwest Section—October 14–17, 1956

Address of Welcome	*Mayor* Woodrow W. Mann
Response	John H. O'Neill
Little Rock's Water Supply	
Administration	H. J. Burford
Water System	Beverly Ryan
New Dam and Spillway	Ernest W. Whitlock
New Pumping Plant	Robert Mitchell
Clearing Reservoir Site	Max A. Mehlburger
Transmission Pipeline	Kenneth W. Lefever
Expansion of Filter Plant	D. N. Dodd
Water and Industry	Winthrop Rockefeller
Reservoir Evaporation Control	B. W. Beadle
Bargain Basement Water Rates	J. W. Heiney
Ratemaking for Small Water Plants	Albert P. Learned
New Trends in Water Treatment Plant Design Practice—Panel Discussion	Clyde R. Harvill, A. A. Kalinske & R. G. Kincaid
Pollution Hazards of Ground Water Supply	John E. Trygg
Methods of Making Fire Flow Tests and Interpretation of Results	George Tatnall
Well Drilling Specifications	Claud Robinson
The Utility, the Plumbing Contractor, and Their Joint Responsibility to the Public	James S. Binder
Peak Demand Storage	S. W. Freese
Operational Problems of the Small Water Plant—Panel Discussion	Charles O. Hall, Foster S. Burba & L. M. McGoodwin
Employee and Supervisor Training	M. L. Powers
Research With Different Types of Water Mains	Paul Weir
Selection of Pumps and Controls for Small Water Plants	W. M. Remsburg & D. W. Robinson

Virginia Section—November 7–9, 1956

Sterilization of Water Transmission Lines....Edward R. Sharp
What Do You Want in a Salesman?....Rollie J. Leveque
The Relationship Between Water Works People and Salesmen....Walker H. Graves
AWWA Specifications as a Tool for Water Works Superintendents....Harry E. Jordan
Taste and Odor Control at Philadelphia....E. L. Bean
Your Responsibilities in Water Tank Maintenance....K. W. Altizer
National and Local Aspects of Water Resources Problems....H. B. Holmes Jr.
Richmond's New Policy on Extension of Utilities....J. E. Metzger
Destruction of Microorganisms in Water and Sewage by Ionizing Radiation....Harry N. Lowe Jr.
Automation in Recent Water Purification Plants....Ellwood H. Aldrich
Use of Activated Silica in Water for Textile Finishing....F. A. Prisley
A Small Water Plant of Novel Design....Richard P. Schmitt
The Unwritten Guarantee....W. Harold Bleakley
Films
  A New Standard of Precision in Microfiltration and Research
  Texas Tower

West Virginia Section—October 31–November 2, 1956

Address of Welcome....William Kell
Pollution Control Progress in the Ohio Valley....Robert K. Horton
US Engineers' Master Plan for West Virginia....H. J. Skidmore
Membrane Filter Laboratory....Woody Seamons
Small Water Plant Construction and Operation
  Burnsville....Wallace Grant
  Ansted....John Millar
Peak Demand Problems
  Huntington....John Edwards
  Charleston....G. S. Bradley
Rate Increase Procedure
  Utility Representative....C. C. MacDonald
  Public Service Commission Representative....Homer W. Hanna Jr.
  Legal Representative....Ben Baer
Panel Discussion—Taste and Odor Problems from Industrial Wastes..*Led by* W. S. Staub, Glen Fortney, John Lester & Lawson Haynes
Distribution Design Criteria....A. E. McCaskey & A. L. P. Schmeichel
Panel Discussion—Fluoridation Safety....*Led by* Dennis Clark, Bern Wright, A. R. Todd & William Hartnett
Films
  Soft as a Cloud
  It's in the Air
  The Second Hundred Years
  Water—Wealth or Worry for America

Wisconsin Section—September 26–28, 1956

Address of Welcome....*Mayor* Milo G. Knutson
Advantages of Using Liquid Alum in Municipal Water Purification Plants....James E. Kerslake
Well Supplies in Wisconsin....F. T. Thwaites
Submersible Pumps....John W. Holmes
Vertical Booster Pumps....S. F. Resan
Use of Plastic Pipe for Water Service....William Hammann
Distribution System Control....Elmer L. Nordness
Rates, Revenues, and Rising Costs....Louis R. Howson
Water Rates....Henry J. O'Leary
Film—The Deep Inch

Section Meetings—1952–1956

Section	*1952*	*1953*	*1954*	*1955*	*1956*	*Meeting Place—1956*
Alabama-Mississippi	Nov. 16–19	Oct. 4–7	Oct. 24–27	Oct. 30–Nov. 2	Oct. 21–24	Mobile, Ala.
Arizona	Apr. 3–5	Apr. 16–18	Apr. 22–24	Apr. 14–16	Apr. 5–7	Safford, Ariz.
California	Apr. 17–19*	——	Apr. 9*	Apr. 15*	Apr. 13*	Fresno, Calif.
	Oct. 28–31	Oct. 27–30	Oct. 26–29	Oct. 25–28	Oct. 23–26	San Diego, Calif.
Canadian	May 26–28	Apr. 6–8	Apr. 12–14	Apr. 18–20	Apr. 23–25	London, Ont.
	Oct. 21–22†	Sep. 21–22†	Oct. 4–5†	Oct. 17–18†	Oct. 15–16	St. John, N.B.
Chesapeake	Oct. 29–31	Oct. 28–30	Oct. 27–29	Oct. 26–28	Oct. 24–26	Baltimore, Md.
Cuban	Dec. 4–6	Dec. 3–5	——	Dec. 1–3	Nov. 29–Dec. 1	Havana, Cuba
Florida	Nov. 16–19	Oct. 11–13	Nov. 7–10	Nov. 6–9	Nov. 11–14	Daytona Beach, Fla.
Illinois	Mar. 26–28	Mar. 18–20	Mar. 17–19	——	Mar. 21–23	Chicago, Ill.
Indiana	Feb. 13–15	Feb. 11–13	Feb. 10–12	Feb. 9–11	Feb. 8–10	Indianapolis, Ind.
Iowa	Oct. 23–25	Oct. 14–16	Oct. 13–15	Oct. 19–21	Oct. 24–26	Des Moines, Iowa
Kansas	May 3	Apr. 22–24	Apr. 7–9	Apr. 13–15	Apr. 4–6	Topeka, Kan.
Kentucky-Tennessee	Sep. 15–17	Sep. 21–23	Sep. 20–22	Sep. 12–14	Sep. 17–19	Chattanooga, Tenn.
Michigan	Sep. 24–26	Sep. 3–4	Sep. 15–17	Sep. 14–16	Sep. 12–14	Kalamazoo, Mich.
Missouri	Sep. 21–23	Sep. 27–29	Sep. 26–28	Sep. 25–27	Sep. 30–Oct. 2	Jefferson City, Mo.
Montana	Apr. 11–12	Apr. 24–25	Apr. 23–24	Apr. 29–30	Apr. 6–7	Livingston, Mont.
Nebraska	Apr. 17–18	Apr. 16–17	Apr. 22–23	Apr. 13–15	Apr. 11–13	Lincoln, Neb.
New England	——	——	——	——	——	——
New Jersey	Oct. 23–25	Oct. 22–24	Nov. 4–6	Oct. 20–22	Oct. 18–20	Atlantic City, N.J.
New York	Apr. 17–18	Apr. 16–17	Apr. 22–23	Apr. 20–22	Apr. 18–20	Utica, N.Y.
	Sep. 4–5	Sep. 9–11	Sep. 9–10	Sep. 7–9	Sep. 12–14	Bolton Landing, N.Y.
North Carolina	Nov. 10–12	Nov. 9–11	Nov. 8–10	Nov. 14–16	Nov. 12–14	Charlotte, N.C.
North Central‡	Sep. 9–12	Sep. 1–5	Oct. 6–8	Oct. 5–7	Sep. 12–14	St. Paul, Minn.
Ohio	Sep. 18–19	Sep. 10–11	Sep. 22–24	Sep. 21–23	Sep. 19–21	Toledo, Ohio
Pacific Northwest	Apr. 24–26	Apr. 16–18	——	May 19–21	Apr. 26–28	Victoria, B.C.
Pennsylvania	Jun. 18–19	Jun. 17–19	Jun. 23–25	May 4–5	Apr. 3–5	Philadelphia, Pa.
Rocky Mountain	Sep. 15–17	Sep. 21–23	Nov. 9–10	Sep. 19–21	Nov. 26–28	Colorado Springs, Colo.
Southeastern	Mar. 24–26	Mar. 23–25	Mar. 29–31	Mar. 20–23	Mar. 18–21	Augusta, Ga.
Southwest	Oct. 12–15	Oct. 18–21	Oct. 17–20	Oct. 16–19	Oct. 14–17	Little Rock, Ark.
Virginia	Nov. 5–7	Nov. 4–6	Nov. 3–5	Nov. 3–5	Nov. 7–9	Old Point Comfort, Va.
West Virginia	Oct. 2–3	Sep. 3–4	Nov. 8–9	Oct. 20–21	Oct. 31–Nov. 2	Bluefield, W.Va.
Wisconsin	Sep. 16–18	Sep. 22–24	Sep. 28–30	Sep. 21–23	Sep. 26–28	La Crosse, Wis.

* Regional meetings. † Maritime Branch. ‡ Formerly Minnesota Section.

Section Membership at Time of, and Total Attendance at, Section Meetings—1952–1956

Section	1952		1953		1954		1955		1956	
	Membership	Attendance	Membership	Attendance	Membership	Attendance	Membership	Attendance	Membership	Attendance
Alabama-Mississippi	169	400‖	177	182	189	311	206	257	219	318
Arizona	71	173	72	41	76	199	68	157	77	156
California§	1,044	1,434	1,084	1,126	1,193	1,709	1,291	1,037	1,378	1,253
Canadian§	582	756	581	617	608	848	629	714	663	816
Chesapeake	241	250	247	224	248	210	258	211	267	191
Cuban	73	52	72	32	69	♯	54	*	52	*
Florida	306	400‖	327	287	328	305	342	306	355	331
Illinois	475	418	482	407	504	474	527	‡	557	468
Indiana	333	392	330	386	332	399	392	475	409	421
Iowa	119	182	121	178	133	191	137	286	149	220
Kansas	187	*	206	170	220	191	229	208	237	236
Kentucky-Tennessee	186	252	186	203	189	294	201	259	221	317
Michigan	319	242	349	164	386	263	411	236	435	278
Missouri	190	225	189	242	198	260	206	230	228	275
Montana	59	168	58	107	55	117	57	76	54	84
Nebraska	75	152	82	224	95	200	94	164	103	183
New England	211	†	218	†	218	†	225	†	233	†
New Jersey	411	311	414	318	436	340	435	313	463	351
New York§	743	375	741	355	805	420	826	315	851	429
North Carolina	182	261	188	294	191	255	202	281	232	326
North Central**	230	179	229	166	241	179	238	162	260	157
Ohio	400	297	403	252	445	406	468	251	482	253
Pacific Northwest	315	267	345	346	441	‡	440	293	438	304
Pennsylvania	433	215	455	204	465	234	493	255	516	295
Rocky Mountain	157	122	156	125	170	100	171	94	186	*
Southeastern	190	220	203	205	246	313	267	325	278	319
Southwest	779	582	938	803	945	681	1,047	850	1,086	889
Virginia	183	237	179	226	188	230	192	237	207	233
West Virginia	98	130	102	120	103	212	100	152	104	126
Wisconsin	176	314	181	288	182	316	190	291	199	296

* No record of attendance.
† No regular meeting scheduled. Membership given as of dates of conferences.
‡ Regular meeting canceled. Business meeting held at annual conference.
§ Only one of section's meetings recorded here.
‖ Joint meeting.
♯ Meeting canceled.
** Formerly Minnesota Section.

Binding the Year's Journals

Through the cooperation of the Library Binding Institute, an organization of binderies which specializes in binding publications into volumes, arrangements have been made to give information and assistance to AWWA members who want to have their JOURNALS bound. This work may be done in accordance with standards of materials and construction required for durability, service, and accessibility by college, reference, and public libraries. The American Library Association and the Library Binding Institute have cooperated in promulgating "Minimum Specifications for Class A Library Binding" based on research and production and performance experience.

A committee of the American Library Association has certified responsible and reliable library binderies which have proved able to meet these specifications. To obtain standard quality binding, simply request Class A binding at any certified bindery. In obtaining price quotations, state the three dimensions of the volume.

Names and addresses of certified binderies in your area are available from the Library Binding Institute, 10 State Street, Boston, Mass. Before sending copies to the bindery:

1. Check for missing issues and check each issue for defects, missing pages, etc. Be sure to include the volume index.
2. Tie the twelve issues together carefully so that nothing is crumpled or torn.
3. Write out definite instructions giving your preferences on the following points:

    a. Color of binding (one of the following standard colors should be selected: dark green, dark blue, black, brown, or medium red).

    b. Whether the advertising sections and/or paper covers are to be bound into the volume.

    c. An exact copy of the text to be lettered in gold on the backbone. A common form is:

Journal—1¾ in. from top	Vol. 48—4¼ in. from bottom
AWWA—2¼ in. from top	1956—3¾ in. from bottom

    d. If you have had JOURNALS bound before and want your set to match as closely as possible, send a previous volume as a sample. If you want an approximate match, send a "rubbing" of the lettering on a previous volume and indicate the color.

If satisfactory arrangements cannot be made, or if there is any difficulty, advise the AWWA office and steps will be taken in cooperation with the Library Binding Institute to assure you proper service.

By arrangement with AWWA, University Microfilms, 313 N. First St., Ann Arbor, Mich., is making a microfilm edition of the JOURNAL available to regular subscribers at a price comparable with the cost of library binding. The cost of the microfilm edition of the 1955 volume was $7.75.

AWWA PUBLICATIONS

*Effective December 15, 1956**

Orders should be sent to the American Water Works Association, Inc., 2 Park Ave., New York 16, N.Y. Payment is required in advance, in US funds, from nonmembers on all orders. Advance payment is required from members on orders totaling less than $2.00.

BOOKS

Index to Journal AWWA (1940–55)—This cloth-bound, 192-p. book, published in 1956, includes subject, author, and geographic indexes to the JOURNAL for the 16 years from 1940 through 1955. Price, for general sales, $4.50; to members paying in advance, $3.60.

Index to Proceedings & Journal AWWA (1881–1939)—This cloth-bound, 285-p. index covers the Proceedings for 1881–1913 and the JOURNAL for 1914–1939. Price, for general sales, $2.00; to members paying in advance, $1.60.

Manual of Water Works Accounting—Prepared jointly by the AWWA and the Municipal Finance Officers Assn., this 500-page Manual contains twenty chapters covering all utility accounting practices. 1938; 2nd printing, 1951. Price, for general sales, $4.00; to members paying in advance, $3.20.

The Quest for Pure Water—By M. N. Baker. A history of water purification from the earliest records to the 20th century. 73 illustrations, 900 references, 527 pp. 1948; 2nd printing, 1949. Price, for general sales, $5.00; to members paying in advance, $4.00.

Standard Methods for the Examination of Water, Sewage, and Industrial Wastes—Published jointly by AWWA, American Public Health Assn., and Federation of Sewage & Industrial Wastes Assns. Cloth bound, 522 pp. Tenth edition, 1955. Price, for general sales, $7.50; to members paying in advance, $6.50.

Survival and Retirement Experience With Water Works Facilities—Prepared by a joint committee of the AWWA and the Institute of Water Supply Utilities. Includes reports published in installments in JOURNAL, 1945–46, with additional material and summary tables. Cloth bound, 566 pp. 1947. Price, for general sales, $3.00; to members paying in advance, $2.40.

Water Quality and Treatment—Prepared by AWWA. A comprehensive survey of water quality standards and procedures for purification, softening and other conditioning. Completely revised and enlarged second edition. 451 pp. 1950; 2nd printing, 1951. Price, for general sales, $5.00; to members paying in advance, $4.00.

MANUALS

Water Rates Manual—M1—A report of the Committee on Water Rates, as published in the March 1954 JOURNAL, plus valuable supplementary data. Paper bound, 64 pp. 1954. Price, for general sales, $1.25; to members paying in advance, $1.00.

Silent Service Is Not Enough!—M2—AWWA public relations study, as published in December 1954 JOURNAL, plus appendix. Paper bound, 152 pp., 1955. Price, for general sales, $1.50; to members paying in advance, $1.20.

Safety Practice for Water Utilities—M3—A manual prepared by the Committee on Safety Practices and originally published serially in the JOURNAL (July–December 1955). Paper bound, 128 pp., 1956. Price, for general sales, $1.50; to members paying in advance, $1.20; to members ordering quantities of 25 or more, $1.00 per copy.

* Listings are revised several times a year.

PERIODICALS AND PAMPHLETS

Journal American Water Works Association. A monthly magazine of technical papers, discussions, news, and reports. Issued quarterly from 1914 to 1919; bimonthly from 1920 to September 1924; monthly ever since. Annual indexes are contained in the December issue of each year from 1940 on. Cumulative indexes of authors and articles grouped by topics are described on p. 1585. Subscriptions to individuals only in conjunction with AWWA membership in US, Canada, and Cuba; to individuals elsewhere, $8.80 per year. Single copy price (issues dated 1954 and later), 85¢; 60¢ to AWWA members. For issues dated 1925–1953, 75¢; to members, 50¢.

The Story of Water Supply. A pictorial presentation designed to acquaint the junior high school student with the history, accomplishments, and workings of public water supplies. Entertaining; instructive. 16 pp., il., 15¢ (quantity prices on request). "Teaching Aids" 5¢ per copy; one free with each 50 copies of *The Story.*

Willing Water. A bimonthly bulletin devoted to public relations, safety, defense, and other special problems. Usually 10¢.

Willing Water Cartoons. A catalog of the *Willing Water* cartoon illustrations available in electrotype or newspaper mat form, for use in printing and advertising work. Also lists postal meter slugs, decals, posters, and other public relations material. No charge.

Your Water Supply. A conservation guide designed as an envelope stuffer for quantity distribution. Includes "how-to" information on reading meters, detecting leaks, replacing faucet washers, saving water generally. 12 pp., il., no charge for single copies (quantity rates on request).

JOURNAL REPRINTS

Order by title and number, not by topic. Copies of Journal articles not available in reprint form can generally be obtained by ordering a copy of the issue in which they were published; for terms, see "Journal AWWA" in preceding "Periodicals and Pamphlets" section. Additional "Reprints Available" are listed in the Journal each month under that heading.

Air Conditioning. No. 263. Model Ordinance. Prepared by AWWA Committee on Water Use in Air Conditioning and Refrigeration. From December 1950 JOURNAL. 8 pp., 20¢.

Air Conditioning. No. R396. Committee Report: Charges for Residential Air Conditioning; and W. V. Weir: Surcharge for Nonconserved Air Conditioning in St. Louis County (both from November 1955 JOURNAL). 15 pp., 25¢.

Analysis. No. 341. Task Group Report: Technique of Bacterial Examination of Water With Molecular Filter Membranes. From November 1953 JOURNAL. 15 pp., 25¢.

Annual Reports. No. 246. Committee Report: Water Department Annual Reports. Includes a guide to the preparation of an annual statistical report. From August 1950 JOURNAL. 14 pp., 20¢.

Costs. No. 334. H. H. Fick: Cost Indexes for Water Works Property. From August 1953 JOURNAL. 11 pp., 25¢.

Costs. No. 379. T. M. Niles: Variations in Construction Costs. From March 1955 JOURNAL. 8 pp., 20¢

Extensions. No. 323. Committee Reports: Water Service for Suburban Areas (from July 1953 JOURNAL), and Water Main Extension Policy (from August 1949). 39 pp., 65¢.

Extensions. No. R394. Panel Discussion: Extension of Public Services to Suburban Areas. From October 1955 JOURNAL. 28 pp., 40¢.

Fire Protection. No. 299. Unofficial Staff Report: Antifreeze Protection for Sprinkler Systems. From February 1952 JOURNAL. 3 pp., 10¢.

Floods. No. 311. Meeting Flood Problems: A Compilation. From September 1952 JOURNAL. 59 pp., 70¢.

Fluoridation. No. R264. F. J. Maier: Fluoridation of Public Water Supplies. From December 1950 JOURNAL. 14 pp., 20¢.

Fluoridation. No. 320. W. W. Land & E. K. Mosenthal. Court Decisions on Municipal Water Fluoridation. From April 1953 JOURNAL. 10 pp., 25¢.

Fluoridation. No. R367. Task Group Report: Census of Fluoridation in the United States and Canada, 1953. From September 1954 JOURNAL. 22 pp., 35¢. [*Supplemented by R398, below.*]

Fluoridation. No. R398. Task Group Report: Census of Fluoridation in the United States and Canada [*1954 supplement to R367, above*]. From December 1955 JOURNAL. 8 pp., 20¢.

Fluoridation. No. R369. W. L. Harris: A Decade of Fluoridation. From October 1954 JOURNAL. 6 pp., 20¢.

Grounding. No. 270. AWWA Policy Statement: Grounding of Electric Circuits on Water Pipe. *Also* C. F. Meyerherm: Water Works Industry's Attitude on Grounding and Stray Current Problems. From April 1944 and December 1945 JOURNALS. 4 pp., 10¢.

Law. No. 318. H. Raines: Legal Liability of Utilities for Service. From March 1953 JOURNAL. 8 pp., 20¢.

Meters. No. 303. O. G. Goldman. Testing and Repairing Small Water Meters. From February 1952 JOURNAL. 10 pp., 15¢.

Operation. No. 370. Panel Discussion: Fundamentals of Water Works Operation. From October 1954 JOURNAL. 15 pp., 25¢.

Pension Legislation. No. 254. Committee Report: State Pension and Retirement Legislation in 1949. From October 1950 JOURNAL. 8 pp., 15¢.

Pipe, plastic. No. R614. W. D. Tiedeman & N. A. Milone. Effects of Plastic Pipe on Water Quality [summary of National Sanitation Foundation research report]. From August 1956 JOURNAL. 5 pp., 20¢.

Pipe, steel. No. 360. J. Hinds: Notable Steel Pipe Installations. From July 1954 JOURNAL. 19 pp., 30¢.

Pipe, steel. No. 388. H. S. Swanson et al.: Design of Wye Branches for Steel Pipe. From June 1955 JOURNAL. 52 pp., 80¢.

Pipe, steel. No. R601. G. E. Burnett & P. W. Lewis: New Developments in Tests of Coatings and Wrappings. From February 1956 JOURNAL. 22 pp., 35¢.

Pollution. No. 361. Task Group Report: Characteristics and Effects of Synthetic Detergents. From August 1954 JOURNAL. 24 pp., 35¢.

Radioactivity. No. 307. Task Group Report: Instrumentation and Methods for Testing Radioactive Contamination of Water. From July 1952 JOURNAL. 12 pp., 20¢.

Regulations. No. 269. California Section Report: Tentative Regulations Governing Water Service. From April 1951 JOURNAL. 14 pp., 20¢.

Resources. No. 278. Morris, Wolman, Pirnie and others. A series of reviews of the President's Water Resources Policy Commission Report. From June 1951 JOURNAL. 32 pp., 30¢.

Resources. No. 295. S. B. Morris: National Water Resources Policy Recommendations. From April 1952 JOURNAL. 15 pp., 20¢.

Resources. No. R393. Panel Discussion: State Water Resources Legislation in 1955. From September 1955 JOURNAL. 13 pp., 25¢.

Safety. No. R395. G. R. McCormack: Labor Department Survey of Injury Rates in Water Industry. From November 1955 JOURNAL. 6 pp., 20¢.

Services. No. 105. Committee Progress Report: A Survey of Service Line Installation Procedures. From November 1952 JOURNAL. 3 pp., 15¢.

Services. No. 175. S. F. Newkirk Jr.: Selection of Customer Service Meters. *Also* M. C. Smith: Experiences With Standards for Water Services. From January and March 1947 JOURNAL. 13 pp., 20¢.

Standards. No. 359. Historical edition of "1908 Cast-Iron Pipe Specifications." From July 1954 JOURNAL. 12 pp., 25¢.

Standards. No. 365. Michigan Section Report: Minimum Standards for Design, Construction, and Maintenance of a Public Water Distribution System. From May 1952 JOURNAL. 10 pp., 25¢.

Standards. No. 374. Chlorine Institute: Recommended Specifications for Stationary Chlorine Storage Installations. From November 1954 JOURNAL. 12 pp., 25¢.

Statistics. A Survey of Operating Data for Water Works in 1950. From June 1953 JOURNAL. No. 322, 96 pp., 60¢. In combination with statistical analysis by Seidel et al. from December 1953 JOURNAL. No. 345, 122 pp., $1.00.

Storage. No. 343. Committee Report: Potable-Water Storage Reservoirs. From October 1953 JOURNAL. 11 pp., 25¢.

Synthetic detergents. No. R361. Task Group Report: Characteristics and Effects of Synthetic Detergents. From August 1954 JOURNAL. 24 pp., 60¢.

Training. No. 340. Committee Report: Status of Training Courses and Certification in the United States. From September 1953 JOURNAL. 26 pp., 40¢.

Treatment. No. 268. Committee Report: Capacity and Loadings of Suspended Solids Contact Units. From April 1951 JOURNAL. 29 pp., 30¢.

Treatment. No. 342. Joint Committee Report: Recommended Procedures in the Use of Chlorine at Water and Sewage Plants. From October 1953 JOURNAL. 15 pp., 25¢.

Treatment. No. R402. Revision of aeration and mixing and sedimentation chapters of *Water Quality and Treatment.* From August and September 1956 JOURNAL. 36 pp., 60¢.

Valves. No. 372. L. Paul: Selection of Valves for Water Works Service. From November 1954 JOURNAL. 20 pp., 30¢.

Watersheds. No. 260. Panel Discussion: Safe Yield From Surface Storage Reservoirs. From September 1950 JOURNAL. 40 pp., 35¢.

Watersheds. No. 363. Panel Discussion: Watershed and Reservoir Control in the Pacific Northwest. From August 1954 JOURNAL. 28 pp., 40¢.

AWWA STANDARDS

Explanation of designation system: AWWA specification designations consist of two elements separated by a dash; e.g., B224–52T. This would designate a specification in the B200 series (dealing with softening) which was approved (or last revised) as Tentative in 1952. If this document were made Standard (with or without revision) in 1957, the designation would become: B224–57. When such a change in status is accompanied by no revisions, or only very minor ones, the new designation is listed, but specifications bearing the earlier designation continue to be furnished by AWWA until existing stocks are exhausted.

A—Source

AWWA A100–52—Standard Specifications for Deep Wells. Approved as Tentative Apr. 30, 1945, and published in the September 1945 JOURNAL. Made Standard May 10, 1946; revised Jun. 18, 1952. 54 pp., 65¢.

AWWA A101–55 (ASA B58.1–1955)—American Standard Specifications for Deep Well Vertical Turbine Pumps. Adopted by AWWA and the American Standards Assn. May 11, 1955, and published in the July 1955 JOURNAL. 27 pp., 50¢.

B—Treatment

B100—Filtration

AWWA B100–50 (formerly 5C–1950)—**Standard Specifications for Filtering Material.** Revision of 1943 document approved as Tentative Nov. 15, 1948, and published in the March 1949 JOURNAL. Made Standard Jan. 16, 1950. 16 pp., 25¢.

B200—Softening

AWWA B200–53 (formerly 5W1.01)—**Standard Specifications for Sodium Chloride.** Approved as Tentative Jul. 6, 1949, and published in the March 1950 JOURNAL. Made Standard May 15, 1953. 10 pp., 25¢.

AWWA B201-53—Standard Specifications for Soda Ash. Approved as Tentative Oct. 15, 1951, and published in the February 1952 JOURNAL. Made Standard May 15, 1953. [*B201-51T current.**] 6 pp., 20¢.

AWWA B202-54—Standard Specifications for Quicklime and Hydrated Lime. Approved as Tentative Sep. 9, 1952, and published in the January 1953 JOURNAL. Made Standard May 27, 1954. 14 pp., 25¢.

AWWA B250-51 (formerly 5Z-1951)—**Standard Manual of Cation Exchanger Test Procedures.** Revision of 1943 document approved as Tentative Dec. 31, 1948, and published in the May 1949 JOURNAL. Made Standard May 4, 1951. 28 pp., 40¢.

B300—Disinfection

AWWA B300-55—Standard Specifications for Hypochlorites. Approved as Tentative Jun. 2, 1953, and published in the October 1953 JOURNAL. Made Standard Jun. 17, 1955. [*B300-53T current.**] 6 pp., 20¢.

B400—Coagulation

AWWA B400-53 (formerly 5W1.10)—**Standard Specifications for Ammonium Sulfate.** Approved as Tentative Jul. 15, 1949, and published in the November 1950 JOURNAL. Made Standard May 15, 1953. 7 pp., 20¢.

AWWA B401-53 (formerly 5W1.30)—**Standard Specifications for Bauxite.** Approved as Tentative Apr. 28, 1950, and published in the July 1950 JOURNAL. Made Standard May 15, 1953. [*B401-50T current.**] 8 pp., 20¢.

AWWA B402-53 (formerly 5W1.31)—**Standard Specifications for Ferrous Sulfate.** Approved as Tentative May 31, 1949, and published in the October 1950 JOURNAL. Made Standard May 15, 1953. 7 pp., 20¢.

AWWA B403-54—Standard Specifications for Aluminum Sulfate. Approved as Tentative Aug. 21, 1952, and published in the November 1952 JOURNAL. Made Standard May 27, 1954. 10 pp., 25¢.

AWWA B404-55T—Tentative Standard Specifications for Liquid Sodium Silicate. Approved as Tentative Aug. 5, 1955, and published in the October 1955 JOURNAL. 7 pp., 20¢.

B500—Scale and Corrosion Control

AWWA B500-53 (formerly 5W1.60)—**Standard Specifications for Trisodium Phosphate.** Approved as Tentative Apr. 3, 1950, and published in the June 1950 JOURNAL. Made Standard May 15, 1953. 6 pp., 20¢.

AWWA B501-53—Standard Specifications for Caustic Soda. Approved as Tentative Oct. 15, 1951, and published in the December 1951 JOURNAL. Made Standard May 15, 1953. [*B501-51T current.**] 6 pp., 20¢.

B600—Taste and Odor Control

AWWA B600-53 (formerly 5W1.70)—**Standard Specifications for Powdered Activated Carbon.** Approved as Tentative Jul. 11, 1949, and published in the February 1951 JOURNAL. Made Standard May 15, 1953. 14 pp., 25¢.

AWWA B601-55—Standard Specifications for Sodium Pyrosulfite. Approved as Tentative Dec. 18, 1953, and published in the January 1954 JOURNAL. Made Standard Jun. 17, 1955. [*B601-53T current.**] 5 pp., 20¢.

B700—Prophylaxis

AWWA B700-49—The Fluoridation of Public Water Supplies. A statement of recommended policy and procedure approved May 29, 1949, and published in the July 1949 JOURNAL. 5 pp., 20¢.

AWWA B701-54 (formerly 5W1.90-T-1950)—**Standard Specifications for Sodium Fluoride.** Approved as Tentative Jul. 21, 1950, and published in the September 1950 JOURNAL. Made Standard May 27, 1954. 7 pp., 20¢.

AWWA B702-55—Standard Specifications for Sodium Silicofluoride. Approved as Tentative May 27, 1954, and published in the August 1954 JOURNAL. Made Standard Jun. 17, 1955. [*B702-54T current.**] 6 pp., 20¢.

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* See explanation of designation system, p. 1588.

AWWA B703-55—Standard Specifications for Fluosilicic Acid. Approved as Tentative Jul. 30, 1954, and published in the November 1954 JOURNAL. Made Standard Jun. 17, 1955. [*B703-54T current.**] 5 pp., 20¢.

C—Distribution

C100—Cast-Iron Pipe, Fittings

AWWA C100-55 (formerly 7C.1-1908)—**Standard Specifications for Cast-Iron Pressure Fittings.** The "special castings" portion of the original 1908 specifications for cast-iron pipe and castings; still valid for replacing old fittings, but superseded by various American Standards (which follow) for new installations. Third edition approved as Tentative Oct. 25, 1954. Made Standard Jun. 17, 1955. [*C100-54T current.**] 30 pp., 55¢.

AWWA C101-39 (ASA A21.1-1939)—American Recommended Practice Manual for the Computation of Strength and Thickness of Cast Iron Pipe. Adopted by AWWA and the American Standards Assn. December 1939 and published in the December 1939 JOURNAL. 81 pp., 65¢. *Revision pending.*

AWWA C102-53 (ASA A21.2-1953)—American Standard Specifications for Cast Iron Pit Cast Pipe for Water or Other Liquids. Adopted by AWWA and the American Standards Assn. December 1939 and published in the December 1939 JOURNAL. Latest revision Jan. 13, 1953. 23 pp., 45¢.

AWWA C104-53 (ASA A21.4-1953)—American Standard Specifications for Cement-Mortar Lining for Cast Iron Pipe and Fittings. Adopted by AWWA and the American Standards Assn. December 1939 and published in the December 1939 JOURNAL. Latest revision, Jan. 13, 1953. 5 pp., 35¢.

AWWA C106-53 (ASA A21.6-1953)—American Standard Specifications for Cast Iron Pipe Centrifugally Cast in Metal Molds, for Water or Other Liquids. Adopted by AWWA and the American Standards Assn. Jan. 13, 1953, and published in the February 1953 JOURNAL. 20 pp., 40¢.

AWWA C108-53 (ASA A21.8-1953)—American Standard Specifications for Cast Iron Pipe Centrifugally Cast in Sand-lined Molds, for Water or Other Liquids. Adopted by AWWA and the American Standards Assn. Jan. 13, 1953, and published in the February 1953 JOURNAL. 24 pp., 45¢.

AWWA C110-52 (ASA A21.10-1952)—American Standard Specifications for Short-Body Cast Iron Fittings, 3 Inch to 12 Inch, for 250-psi Water Pressure Plus Water Hammer. Adopted by AWWA and the American Standards Assn. Sep. 30, 1952, and published in the November 1952 JOURNAL. 10 pp., 35¢.

AWWA C111-53 (ASA A21.11-1953)—American Standard Specifications for a Mechanical Joint for Cast Iron Pressure Pipe and Fittings. Adopted by AWWA and the American Standards Assn. Jan. 13, 1953, and published in the April 1953 JOURNAL. 12 pp., 35¢.

C200—Steel Pipe

AWWA C201-50 (formerly 7A.3-1950)—**Standard Specifications for Electric Fusion Welded Steel Water Pipe of Sizes 30 Inches and Over.** Published as Tentative in the January 1940 JOURNAL and made Standard Apr. 25, 1940. Latest revision Jun. 21, 1950. 20 pp., 30¢.

AWWA C202-49 (formerly 7A.4-1949)—**Standard Specifications for Steel Water Pipe of Sizes up to But Not Including 30 Inches.** Published as Tentative Revision of 1941 document in the April 1943 JOURNAL. Made Standard Oct. 3, 1949. Latest revision Jun. 21, 1950. 28 pp., 40¢.

AWWA C203-55—Standard Specifications for Coal-Tar Enamel Protective Coatings for Steel Water Pipe of Sizes 30 Inches and Over. Published as Tentative in the January 1940 JOURNAL and made Standard Apr. 25, 1940. Latest revision July 14, 1955. 28 pp. (reprinted under same cover as AWWA C204-55, description of which follows).

* See explanation of designation system, p. 1588.

AWWA C204–55—Standard Specifications for Coal-Tar Enamel Protective Coatings for Steel Water Pipe of Sizes up to But Not Including 30 Inches. Published as Tentative in the January 1940 JOURNAL and made Standard Apr. 25, 1940. Latest revision July 14, 1955. 24 pp. (reprinted under same cover as AWWA C203–55), 60¢.

AWWA C205–41 (formerly 7A.7–1941)—**Standard Specifications for Cement-Mortar Protective Coatings for Steel Water Pipe of Sizes 30 Inches and Over.** Published as Tentative in the January 1940 JOURNAL and made Standard Jun. 26, 1941. Latest revision October 1956. 16 pp., 25¢.

AWWA C206–50 (formerly 7A.8–1950)—**Standard Specifications for Field Welding of Steel Water Pipe Joints.** Approved as Tentative Jan. 10, 1946, and published in the March 1946 JOURNAL. Made Standard Nov. 27, 1950. Latest revision Oct. 3, 1949. 12 pp., 25¢.

AWWA C207–55—Standard Specifications for Steel Pipe Flanges. Approved as Tentative May 9, 1952, and published in the October 1952 JOURNAL. Made Standard Jun. 17, 1955. [*C207–54T (seventh printing) current.**] 6 pp., 25¢.

AWWA C208–55T—Tentative Standard Specifications for Dimensions for Steel Water Pipe Fittings. Approved as Tentative Jul. 14, 1955, and published in the July 1956 JOURNAL. 12 pp., 25¢.

C300—Concrete Pipe

AWWA C300–52 (formerly 7B.1)—**Standard Specifications for Reinforced Concrete Water Pipe—Steel Cylinder Type, Not Prestressed.** Approved as Tentative Dec. 11, 1947, and published in the March 1948 JOURNAL. Revised and made Standard Jun. 13, 1952. 14 pp., 25¢.

AWWA C301–55T—Standard Specifications for Reinforced Concrete Water Pipe—Steel Cylinder Type, Prestressed. Second edition approved as Tentative Jun. 17, 1955. 18 pp., 30¢.

AWWA C302–53—Standard Specifications for Reinforced Concrete Water Pipe—Noncylinder Type, Not Prestressed. Approved as Tentative Sep. 4, 1951, and published in the October 1951 JOURNAL. Made Standard May 15, 1953. 15 pp., 25¢.

C400—Asbestos-Cement Pipe

AWWA C400–53T—Tentative Standard Specifications for Asbestos-Cement Water Pipe. Approved as Tentative May 15, 1953, and published in the July 1953 JOURNAL. 8 pp., 20¢.

C500—Valves and Hydrants

AWWA C500–52T (formerly 7F.1)—**Tentative Standard Specifications for Gate Valves for Ordinary Water Works Service.** Revision of 1938 document approved May 9, 1952, and published in the September 1952 JOURNAL. Latest revision April 1954. 16 pp., 25¢.

AWWA C501–41T (formerly 7F.2–T–1941) —**Tentative Specifications for Sluice Gates.** Approved as Tentative Jun. 26, 1941, and published in the October 1941 JOURNAL. 11 pp., 25¢.

AWWA C502–54 (formerly 7F.3)—**Standard Specifications for Fire Hydrants for Ordinary Water Works Service.** Revision of 1940 document approved Mar. 16, 1953, and published in the May 1953 JOURNAL. Made Standard May 27, 1954. [*C502–53 current.**] 12 pp. (printed under same cover as C503–37, description of which follows), 25¢.

AWWA C503–37 (formerly 7F.3.1–1937)—**Standard Specifications for Uniform Marking of Fire Hydrants.** Published as Tentative in the April 1937 JOURNAL and made Standard Jun. 7, 1937. (Printed under same cover as C502).

AWWA C504–55T—Tentative Standard Specifications for Rubber-seated Butterfly Valves. Approved as Tentative May 27, 1954, and published in the September 1954 JOURNAL. Revised Nov. 7, 1955. 16 pp., 25¢.

AWWA C505–55T—Tentative Standard Specifications for Metal-seated Butterfly Valves. Approved as Tentative Nov. 10, 1955, and published in the February 1956 JOURNAL. 16 pp., 25¢.

C600—Pipelaying

AWWA C600–54T (formerly 7D.1–T–1949) —**Tentative Standard Specifications for Installation of Cast-Iron Water Mains.**

* See explanation of designation system, p. 1588.

Revision of 1938 document approved as Tentative Jun. 3, 1949, and published in the December 1949 JOURNAL. Revised May 27, 1954. 33 pp., 50¢.

AWWA C601-54 (formerly 7D.2)—**A Standard Procedure for Disinfecting Water Mains.** Revision of 1947 document approved as Tentative Mar. 6, 1953, and published in the August 1953 JOURNAL. Reprinted together with commentary, "Revised Main Disinfection Procedure," by Marshall P. Crabill. Made Standard May 27, 1954. 12 pp., 25¢.

AWWA C602-55—Standard Specifications for Cement-Mortar Lining of Water Pipelines in Place—Sizes 16 Inches and Over. Approved as Tentative May 27, 1954, and published in the October 1954 JOURNAL. Made Standard Jun. 17, 1955. [*C602-54T current.**] 8 pp., 25¢.

C700—Meters

AWWA C700-46 (formerly 7M.1-1946)—**Standard Specifications for Cold Water Meters—Displacement Type.** Published as Tentative in the December 1941 JOURNAL and made Standard May 10, 1946. 12 pp., 25¢.

AWWA C701-47 (formerly 7M.2-1947)—**Standard Specifications for Cold Water Meters—Current Type.** Published as Tentative in the April 1946 JOURNAL and made Standard Jul. 25, 1947. 12 pp., 25¢.

AWWA C702-47 (formerly 7M.3-1947)—**Standard Specifications for Cold Water Meters—Compound Type.** Published as Tentative in the April 1946 JOURNAL and made Standard Jul. 25, 1947. 11 pp., 25¢.

AWWA C703-49 (formerly 7M.4-1949)—**Standard Specifications for Cold Water Meters—Fire Service Type.** Published as Tentative in the February 1947 JOURNAL and made Standard Jan. 18, 1949. 12 pp., 25¢.

AWWA C704-50 (formerly 7M.5-1950)—**Standard Specifications for Cold Water Meters—Current Type—Propeller Driven.** Approved as Tentative Jul. 21, 1949, and published in the August 1949 JOURNAL. Made Standard May 25, 1950. 12 pp., 25¢.

C800—Service Lines

AWWA C800-55—Standard Specifications for Threads for Underground Service Line Fittings. Approved as Tentative Jul. 25, 1947, and published in the October 1947 JOURNAL. Made Standard Sep. 15, 1948. Revised Jan. 17, 1955. Included under same cover is "Collected Standard Specifications for Service Line Materials," a committee report. 15 pp., 25¢.

C900—Records and General

AWWA C900-40 (formerly 7G.1-1940)—**Recommended Practice for Distribution System Records.** Approved Jan. 16, 1940, and published in the February 1940 JOURNAL. Included under same cover are reprints of "Economies in Office Forms" by Israel Rafkind and "Coordinating Operating System Records With Accounting Records" by Nathan B. Jacobs. 52 pp., 60¢.

D—Storage

AWWA D100-55—Standard Specifications for Steel Tanks, Standpipes, Reservoirs, and Elevated Tanks, for Water Storage. Latest revision June 7, 1955. Combined with AWWA D102, description of which appears below, in a single booklet. 72 pp., 80¢.

AWWA D101-53 (formerly 7H.2)—**Recommended Practice for Inspecting and Repairing Steel Tanks, Standpipes, Reservoirs, and Elevated Tanks, for Water Storage.** Revision of 1949 document approved May 9, 1952. Combined with AWWA D102, description of which appears below, in a single booklet. Made Standard May 15, 1953. 32 pp., 50¢.

AWWA D102-55T—Tentative Recommended Practice for Painting and Repainting Steel Tanks, Standpipes, Reservoirs, and Elevated Tanks, for Water Storage. Approved by AWWA as Tentative May 9, 1952, and published in the August 1952 JOURNAL. Available only in combination with AWWA D100 or AWWA D101, prices of which are given above. Last revised Aug. 5, 1955.

* See explanation of designation system, p. 1588.

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Pure Oil Building
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2775 S. Moreland Boulevard
Cleveland 20, Ohio

Percolation & Runoff

Comes Christmas, comes the revelation—the disanonymization, that is, of P&R's patrons of the year past. Having forced them into a state of complete obliteracy for a full 11 months, merely by appointing them to the supersecret order of Editors Anonymous, we succumb now—as every December—to a Christmas-stricken conscience and admit that it was they, not we, who managed to pull P&R through another year. And lest they be more taken to task than honored for their deed, we hasten to assure that the various clippings and other contributions provided by these Editorial Anonymice were, P&Rticles to the contrary nottheleastbitwithstanding, neither inarticulate nor insensible. As a matter of fact, any incomprehensibilities must be blamed directly on the prister . . . the plinter . . . the frinter (well, you see the problem!).

For the past year—the ninth of P&Rism—the tally of contributions and contributors set new records, lining up not only a record roll of 47 Editors Anonymous, but no less than eleven "Incurables," including, of course, those still anonymost, Ellsworth Filby, Joe Wafer, and Syd Wilson, who have been gone guys ever since the start. The full roster is included below, but lest some uninitiated prospect tend to get busy at the wrong clip joint, we hasten to note once more that the classifications employed are based strictly upon the number of likely stories provided as material for P&R's "treatment." Thus, the *Incurables* are those whose scissors are practically barberian; *Deetees,* somewhat less snippy; *Shakes,* only occasional clipsters; and *Jitters,* the rarer, and often unawarer, ones:

Incurables

C. H. Capen[9]	W. R. LaDue[6]
E. L. Filby[9]	C. G. Painter[4]
D. N. Fischel[9]	R. L. Tyler[5]
R. E. Hansen[8]	J. M. Wafer[9]
M. J. Harper[4]	Henry Wilkens[4]
P. S. Wilson[9]	

Deetees

E. A. Sigworth[8]	W. V. Weir[7]
G. E. Symons[7]	D. B. Williams[5]

Shakes

D. C. Colebaugh[3]	G. J. Manahan[3]
Garvin Dyer	L. S. Morgan
W. B. Kirchman[4]	J. S. Rosapepe[2]

Jitters

F. C. Amsbary Jr.	J. L. Hawkins[2]
N. M. deJarnette[5]	G. H. Holl
J. E. Drudy	V. C. Lischer
H. A. Faber	W. S. Mariner
G. E. Ferguson[4]	Fred Merryfield
M. E. Flentje[5]	R. S. Millar
J. L. Ford[8]	B. E. Payne[4]
J. A. Frank[3]	H. G. Reichardt
A. J. Gates	H. F. Seidel
James Girand	Brian Shera
Warren Gold	H. J. Spaeder
N. J. Goode[8]	Paul Weir
Philip Grannan	J. F. Zieserl[8]

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This perfect 47 we, at least, salute —and have saluted for as many years as the powers they be denote. To them we credit—if others may blame—the not entirely serious portions of P&R, and, wishing them, as well as P&Readers everywhere a very Merry Christmas, we can't help look forward to another year when Editors Anonymous will be working toward "All the Clippings We Need, When and Where We Need Them!"

The Water Resources Div. of the US Geological Survey has been reorganized for the purpose of integrating program planning and operations, decentralizing administration, and improving facilities for general hydrologic studies. The division chief, Carl G. Paulsen, will be represented in the field by four "division hydrologists," a position which carries responsibilities for program review and guidance, coordination of operations, maintenance of general relations with outside organizations, and occasionally conducting personal research.

George E. Ferguson, formerly chief of the division's Program Control Branch, has been named division hydrologist for the Atlantic Coast Area. His counterpart in the Pacific Coast Area is Arthur M. Piper, staff scientist. Representatives for the Rocky Mountain and Mid-Continent areas will be named later.

A new branch—General Hydrology, headed by Charles C. McDonald—has been added to the existing three division branches (Ground Water, Surface Water, Quality of Water). The reorganization also provides the division chief with two assistants, one for operations (Raymond L. Nace) and the other for program and development (Luna B. Leopold).

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John H. Murdoch Jr. will retire next month as vice-president and general counsel for American Water Works Co., but will continue as consultant and as director of some of its

subsidiaries. He has been attorney for the firm since 1936 and was associated with its constituent companies for many years prior.

That AWWA means more than ever is a fact we've been promoting for many, many years. Only the other day, though, did we realize that AWWA means even more than that. This new-even-to-us meaning is "American White Water Affiliation," the name of "an affiliation of outdoor groups, outing associations, canoe clubs, foldboat clubs, ski clubs, hiking groups, and all other groups interested in river touring." The fact that the purpose of the boat AWWA is as healthful as that of the glass AWWA helps; and the fact that the journal of the boat AWWA is a quarterly called *American White Water* will also subtract from the confusion. As the doc's AMA has learned to live with the exec's AMA, as the lawyer's ABA has

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learned to live with the banker's ABA, and even the baker's ABA, we imagine that AWWA will manage to get along with AWWA, as long as the members of AWWA keep off the product of the members of AWWA.

George E. Symons, consultant and technical editor, has discontinued his private practice to become executive vice-president and editorial director of Scranton Publishing Co., Inc., New York. He will supervise all fiscal, production, and editorial operations of *Water & Sewage Works, Industrial Wastes, Modern Highways,* and books published by the firm. He will also supervise market studies and will be co-editor of the Reference and Data Number of *Water & Sewage Works.* For the past 5 years, Dr. Symons has served as consultant and technical editor to B-I-F Industries, Inc., Providence, R.I., and the Pacific Flush Tank Co., Chicago. He also did free lance writing for numerous publications.

The Chlorine Institute, formerly located at 50 E. 41st St., New York, has moved to 342 Madison Ave., New York 17.

Vinton W. Bacon, executive officer, California Water Pollution Control Board, has been awarded a 1956 research prize by ASCE, "in recognition of achievements in applied research on waste water reclamation, pollution, and water quality."

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Fordin' Along...

One of the most common "myths" in the understanding of water pressure is that objects "seek their own level" when sinking at sea. Following the sinking of the Titanic, thousands inquired as to the depth at which the boat would come to rest. The answer is, of course, the bottom of the sea. In spite of the tremendous pressures involved, the specific gravity of water remains practically unchanged. Any object that is permeable (porous in the slightest degree) and that sinks at sea level will continue to sink no matter what the depth of the water.

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The stock market—$tock, that is—and the water works have always appeared to be on opposite ends of town, but in this age of rapid transportation and rapider communication, there appear to be signs that even they are just a little closer. Not many months ago, for instance, Citizens Utilities Co., which operates a number of small water works in various parts of the country, actually taught Wall Street a trick when it made available to its stockholders two kinds of shares—one paying dividends in cash only, the other in stock only. Then Nathanael V. Davis, president of Aluminium Ltd., crossed town in the opposite direction when he opened the annual meeting of Aluminium stockholders by describing the impact of water shortage on the aluminum business. And finally, really looking for signs, we noted that "MGD" became an official abbreviation on the "Big Board." This, unfortunately, turned out to be no more than the first listing of McGregor-Doniger Inc. on the New York Stock Exchange, but, then, it wasn't so long ago that a feature article of *The Exchange* was on water supply and water suppliers. Next thing we know, instead of watered stock, the Street will be talking about stocked, not to mention bonded, water, and "All the Water You Need, When and Where You Need It!" will be a $hoo in!

J. Homer Sanford, consulting ground water hydrologist, has opened new headquarters at 1143 E. Jersey St., Elizabeth, N.J. His office was formerly located in New York City.

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Employment Information

Because of a recent large increase in the volume of requests for the publication of employment information, the JOURNAL has decided to change its policy and, on a trial basis, to accept classified advertising under this heading, beginning with the March 1957 issue. Categories will be limited to "Positions Available" and "Positions Wanted."

Advertisements will be printed in 6-point type, and will be charged at the rate of $1.50 per line (minimum charge, $5.00), *payable in advance.* (In calculating charges, assume six words per line, count *each* element of a compound word or proper name as one word, count each word to be printed all in CAPITALS as two words.)

Copy must be received no later than the first of the month prior to that in which the ad is intended to appear (i.e., for March, the deadline is Feb. 1). Copy and payment should be sent to: Classified Ad Dept., Journal AWWA, 2 Park Avenue, New York 16, N.Y.

Positions as public health engineers, Grades III and IV, are available with the Wisconsin Board of Health. Qualifications for Grade III, which carries a starting salary of $6,108, include an engineering degree and a year's experience. For Grade IV (starting salary $6,648), graduate training and 3 years' experience are required. Write Personnel Officer, State Board of Health, Madison 2, Wis.

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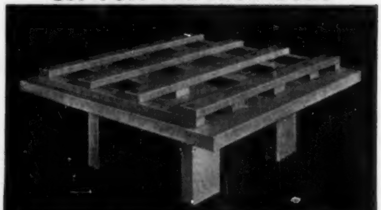
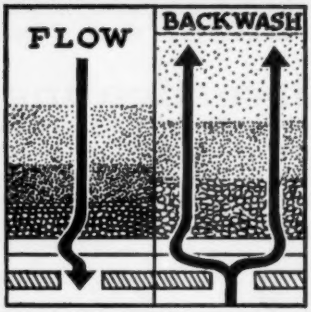
US Civil Service engineering positions are available with the Potomac River Naval Command, in and near Washington, D.C., and the US Army Engineer Center, Fort Belvoir, Va. Starting salaries range from $4,480 to $11,610. Details and application forms can be obtained from regional US Civil Service offices or from Executive Secretary, Board of US Civil Service Examiners for Scientific & Technical Personnel of Potomac River Naval Command, Bldg. 72, Naval Research Lab., Washington 25, D.C.

Water's powers, about which we have waxed almost lyrical at times, seem now about to be extended still further by the invention of water-soluble fabrics. As described by Dr. J. David Reid of the US Dept. of Agriculture's Southern Utilization Research Branch, soluble fabrics and threads have already found uses in making self-removing ties for skinless sausage links, in producing lace by embroidery on soluble cloth, and in providing water-soluble filters for trapping airborne microorganisms in studies of respiratory irritants. Restraining ourself from any mention of the interesting possibilities in the bathing suit business, we can, nevertheless, welcome the news that several processes for water-solubilizing cotton without seriously impairing fiber strength have already been developed. After all, these processes provide the means by which water can be made still more useful to industry, science, and, shall we say, entertainment.

(*Continued on page 50 P&R*)





(Continued from page 48 P&R)

Harvey F. Ludwig has resigned as chief of the Office of Engineering Resources, Div. of Sanitary Engineering Services, USPHS, to accept a position as executive assistant to the manager of Hycon Aerial Surveys, Pasadena, Calif. His successor is Frank A. Butrico, formerly assistant chief.

Marshall P. Crabill, manager of operations, Indianapolis Water Co., has been elected vice-president—operations for that firm.

Samuel F. Turner, consulting water geologist, has joined with Robert L. Wells, consulting mining geologist, to form Turner & Assocs., with offices at 350 E. Camelback Rd., Phoenix, Ariz.

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Mason G. Lockwood, senior partner in the consulting engineer firm of Lockwood, Andrews & Newnam, Houston, Tex., has been elected president of ASCE. He succeeds Enoch R. Needles, of New York. Francis S. Friel, president of Albright & Friel, consulting engineers, Philadelphia, and Norman R. Moore, chief of the Engineering Div., Mississippi River Commission, Vicksburg, Miss., are the new vice-presidents.

Arizona water table declines of as much as 30 ft in 1955 were described in a recent US Geological Survey report. The 4,400,000 acre-ft of ground water pumped during 1955, however, was 100,000 acre-ft less than in 1954. The slight decrease was attributed to greater than average precipitation and to a small reduction in cultivated acreage.

Harold L. Crane, superintendent, Elizabethtown Water Co., Elizabeth, N.J., died Oct. 17, 1956, at the age of 66. A life-long resident of Elizabeth, he was employed by the company for 36 years. He had been an AWWA member since 1935.

Theodore W. Hacker, a partner in the engineering firm of Whitman, Requardt & Assocs., Baltimore, died Sep. 22, 1956, at his home on Gibson Island, Md., after an illness of several months. Born in New York City, he spent practically all his life in Baltimore. He was graduated with a degree in civil engineering from Cornell

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University in 1917 and immediately joined Whitman, Requardt, with which he remained until his death, except for a period of naval service in World War I and a term as adviser on water supply to the government of Thailand (then Siam) in 1931–34. He was in charge of all construction work for his firm.

An AWWA member since 1954, he also belonged to ASCE, American Public Works Assn., and Maryland Assn. of Professional Engineers.

Fred P. Stradling, manager, Bristol County, R.I., Water Co., Bristol, died Nov. 10, 1956, at the age of 59. Born in Muncie, Ind., in 1897, he received his education from schools there and from the Muncie Normal Institute. After a start in the newspaper business, he joined the Muncie Water Works Co. in 1918 as cashier, and 2 years later transferred to the Kokomo, Ind., Water Works Co., of which he became manager 4 years later. In 1941 he became vice-president and assistant to the president of American Water Works & Electric Co., New York, helping to manage thirteen water utilities in seven states. In 1943 he became assistant manager of the East St. Louis, Ill., & Interurban Water Co., and in 1947 assumed the position of manager at Bristol.

A Life Member of AWWA (joined in 1924), he was chairman of the Indiana Section in 1933 and served a term as director for the New England Section in 1953–56.

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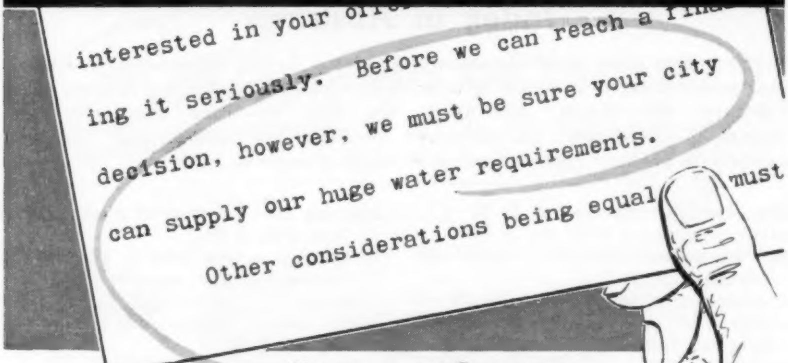

"we must be sure your city can supply our huge water requirements"

When an industry seeks a new plant location, this is one of the first questions asked of a community.

Executives of industry want to know that a community's water supply is ample for product processing, cooling, boiler feed, sanitation and service purposes. They want assurance of an adequate reserve capacity for peak requirements and future plant expansion.

If prospects are bright for your community's industrial development in the period ahead, don't let lack of water stymie its progress. Plan *now* to supply the water industry wants.

Equally important as *adequate* water is its *dependable* delivery. That's why—

Permanent and Trouble-Free CAST IRON PIPE *should be specified*

Because of its century or more of useful life, its high capacity as a carrier and negligible maintenance cost, Cast Iron Pipe has earned its reputation as "America's No. 1 Tax Saver."

Our Company does not manufacture pipe, but has long supplied the nation's leading pipe manufacturers with quality iron from which quality pipe is made.

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WOODWARD, ALABAMA

Condensation

Index of Abstracts

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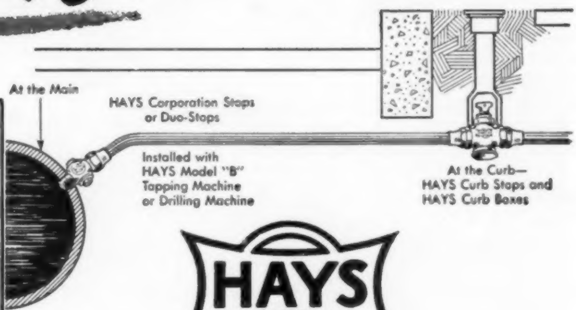
For Trouble-Free Service at *Both* ENDS OF THE LINE

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ROUNDWAY CURB STOP


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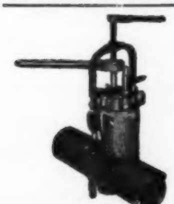
MODEL "B" TAPPING MACHINE

HAYS®

WATER SERVICE PRODUCTS

For underground installations, only the *highest quality* should be considered . . . that's why Water Departments all over the country have been using HAYS Water Service Products for over 80 years.

HAYS makes a complete line of Corporation and Curb Stops conforming to all A.W.W.A. Standards.

Have you investigated the advantages of the HAYS DUO-STOP, (a combined Corporation Stop and Saddle) for safe and easy installation on small service lines?

The HAYS Model B Tapping Machine, with aluminum alloy body, is ⅓ lighter, easier to carry, easier and faster to operate, gives more working room . . . really designed for "the man in the ditch."

Write for literature or ask "The Man from Hays."

Join the A. W. W. A. HAYS is one of the eleven Charter Members of the Manufacturers Section of the American Water Works Association.

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WATER WORKS PRODUCTS
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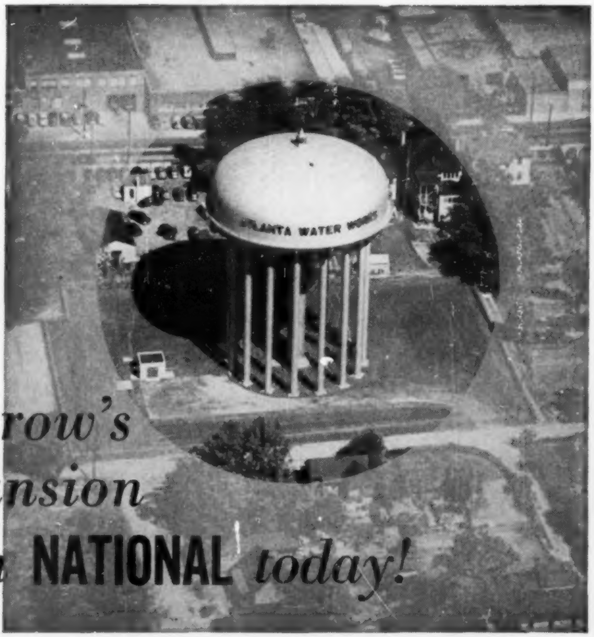

For tomorrow's expansion call in **NATIONAL** *today!*

Like Atlanta, Ga., *you* too can meet tomorrow's increased water demands with *clean water mains.* When the coefficient of sections of Atlanta's 45 year old main dropped to a low of 44, Waterworks General Manager, Paul Weir ordered National cleaning. Results were outstanding. Water pressure and capacity doubled, giving better fire protection and higher water pressure to outlying sections.

Do as other leading cities have done—let *National* cleaning provide for tomorrow's expansion without capital expenditure today! We can prove that National cleaning is an investment—not an expense.

Write us today!

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despite rapid turbidity jumps ...50 to 1500 ppm in 6 hours!

GROWTH OF POPULATION and increasing odors in their settling basins caused by river sewage and oil-field wastes persuaded Mount Carmel officials to look for a more efficient water-treatment plant. The new plant would have to deliver twice as much water. It would have to eliminate odors. And it would have to handle sudden spurts of *high* turbidity.

HOW IT'S DONE: A suspended sludge-blanket type of equipment was indicated, and a Permutit Precipitator was installed. Now they get 2½ mgpd of clear water *in half the time* it took the two old settling basins to treat only 1½ mgpd! All with *no increase in manpower.* There are no more bad odors during treatment. Chemical costs are lower.

FILTER SAVINGS: Two new filters were added to the existing three filters . . . both with Permutit Monocrete® Underdrain Systems that are noncorrodible, low in cost, easily constructed.

AUTOMATIC FEATURES: Mount Carmel's Precipitator has photoelectronic control. The unit is automatically blown down in direct proportion to the flow rate and the amount of total solids precipitated. Since the controls on the three existing filters were obsolete, five new gravity filter operating tables were installed to control backwashing and filtering automatically!

"Everything is running smoothly. We're getting a better grade of water . . . clearer water," reports Supt. Elmo Conrady.

"It's all automatic. Mud goes right back into the river . . . eliminating the cleaning of basins," reports Chief Operator Cedric Seaton.

"It has given excellent performance since operation began," report Warren & Van Praag, Inc., Consulting Engineers, Decatur, Illinois.

PERMUTIT WILL WORK WITH YOU to modernize your present plant or to plan a new one. Call us early in planning so we can be of most help. The Permutit Company, Dept. JA-12, 330 West 42nd Street, New York 36, N. Y.

PERMUTIT®
WATER CONDITIONING
Equipment • Resins • Experience

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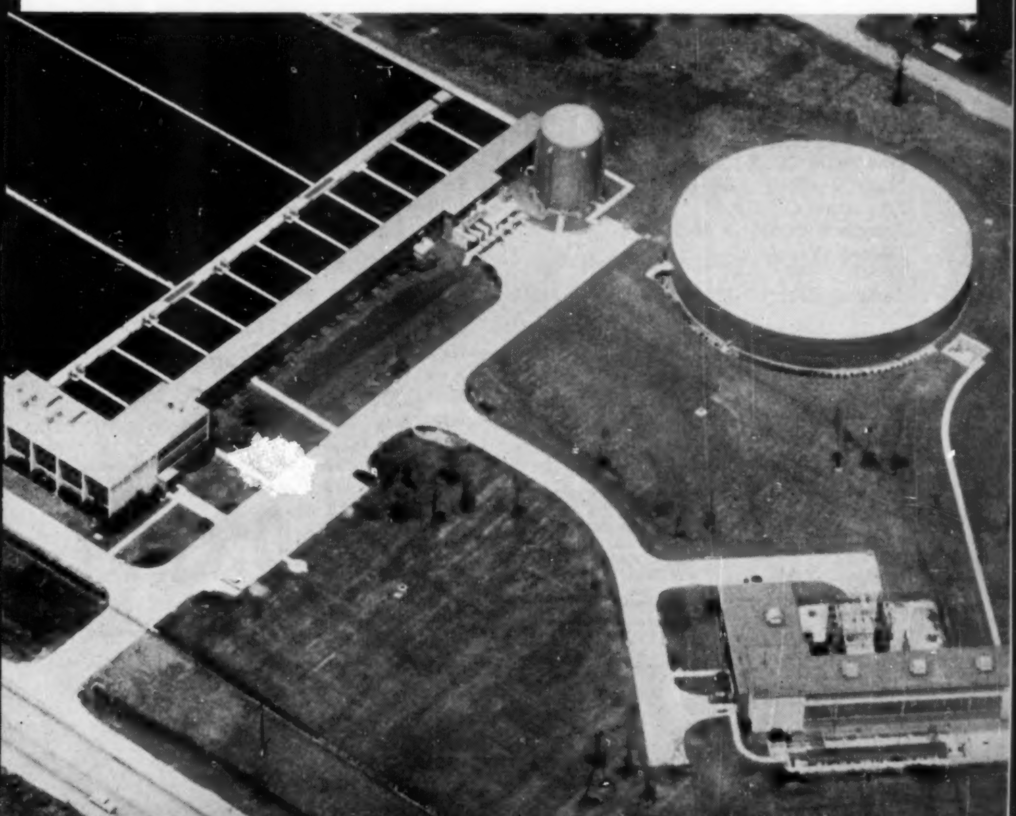

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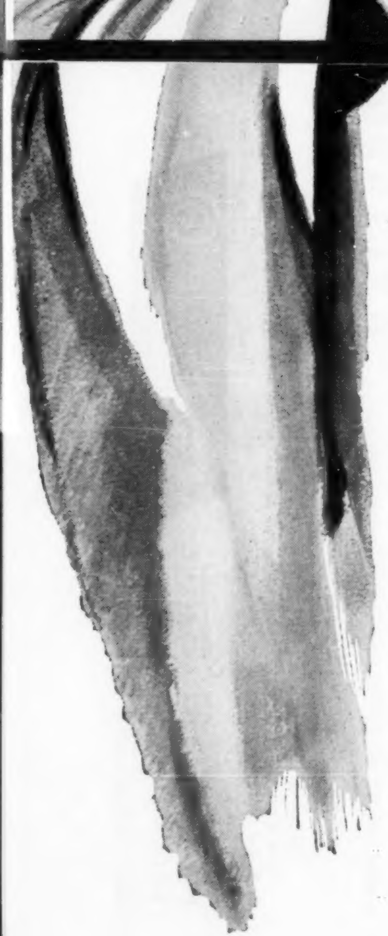

and not abandon our land

"There are mountains in Attica which can now keep nothing . . . but which were clothed, not so very long ago, with fine trees producing timber . . . while the country produced boundless pasture for cattle . . ."

As early as 300 B.C., when Plato thus lamented a tragedy of exhausted natural resources, there was little left of Attica's fertility — only insects crawling about the *"sites of extinct water supplies."* A lesson 2000 years old, to be heeded if we would escape the fate of Attica.

And the first logical step in vital water conservation is to replace flat, waste-conducive rates with Badger Metering.

The demand for water is at its peak in our history. All classes of users compete for more and *more.* A 75% increase in consumption is expected by 1975. In some areas the situation is already critical.

Curtailing waste with Badger Meters — fairly apportioning the responsibility and accounting for water use — is not only a sound investment in your community's future, but essential to its very survival.

The time to act is now — while there's still some water left to save! Write today for information on Badger Meters, or to arrange for a representative to call.

Water is Vital

Badger Water Meters

Badger Meters have conserved it for 50 years

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Armantrout, A. J., Supt., New Market, Ind. (Oct. '56) *MD*

Armbruster, George, Pres., Town Board, Brookville, Ind. (Oct. '56) *MPD*

Atchley, Robert M., Chief Chemist, Arkansas Power & Light Co., 4th & Louisiana Sts., Little Rock, Ark. (Oct. '56) *MRP*

Baker, Montelle M., Engr., Commonwealth Edison Co., Chicago, Ill. (Oct. '56)

Barnes, E. P., Morton Salt Co., 4711 E. 34th St., Indianapolis, Ind. (Oct. '56) *P*

Bass, G. A.; *see* Bass, George A., Constr. Co.

Bass, George A., Construction Co., G. A. Bass, Pres., Birmingham Theater Bldg., Birmingham, Mich. (Assoc. M. Jul. '56)

Bell, John C., Water Services Coordinator, Civic Center, San Diego, Calif. (Oct. '56) *D*

Bloom, Rubin S., Water Chemist, South Dist. Filtration Plant, 3300 E. Cheltenham Pl., Chicago, Ill. (Oct. '56) *P*

Brainard, F. S., & Co., Frank S. Brainard Jr., Vice-Pres., 246 Palm St., Hartford, Conn. (Assoc. M. Oct. '56)

Brainard, Frank S., Jr.; *see* Brainard, F. S., & Co.

Britz, Harold M., Sr. Assoc. Civ. Engr., Dept. of Water Supply, 735 Randolph St., Detroit 26, Mich. (Oct. '56)

Brown, Jack Duane, Field Engr., Fairbanks, Morse & Co., 2017 Dean Ave., Des Moines, Iowa (Oct. '56) *D*

Bruce, Robert D., Sales Engr., Link-Belt Co., 136—4th St., Louisville, Ky. (Oct. '56) *P*

Carlson, Robert L., Sales Engr., 533 Hollis Rd., Charlotte 3, N.C. (Oct. '56) *P*

Cecil, Carl, Accountant, Carl Cecil & Assocs., 712 W. 43rd St., Indianapolis, Ind. (Oct. '56) *MRPD*

Collis, B. Coleman, Sr. Utility Engr., State Public Service Com., Frankfort, Ky. (Oct. '56) *MPD*

Combination Pump Valve Co., Warren G. Engle, Pres., 851 Preston St., Philadelphia 4, Pa. (Assoc. M. Oct. '56)

Connelley, E. J. Jr., Sales Engr., The Permutit Co., 920 E. 38th St., Indianapolis, Ind. (Oct. '56) *P*

Conover, Clyde Stuart, Dist. Engr., Ground Water Branch, US Geological Survey, Box 302, University Sta., Albuquerque, N.M. (Oct. '56) *R*

Cook, Charles F., Salesman, Warren Chem. Co., Inc., Chicago Heights, Ill. (Oct. '56) *P*

Cook, K. S., Engr., Warren Chem. Co., Box 105, Chicago Heights, Ill. (Oct. '56) *P*

Coultas, Robert, Foreman, Water Dept., Tell City, Ind. (Oct. '56) *MPD*

Covey, Harry H.; *see* National Tank Maintenance Corp.

Cox, W. P., Jr.; *see* Southeastern Contracting Co.

Cripe, Maurice V., Supt., Water Dept., Boswell, Ind. (Oct. '56) *MRPD*

Curry, Jesse Earl, Jr., Supt., West Virginia Water Service Co., Madison, W.Va. (Oct. '56)

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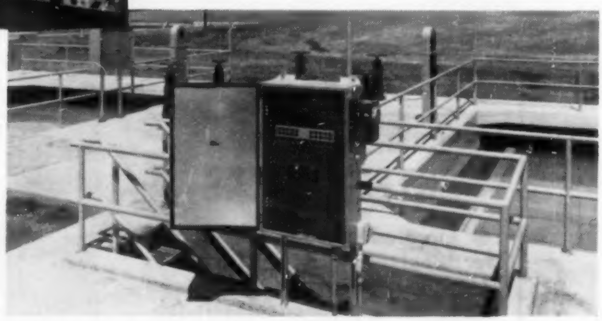
building block control systems

. . . OUTSTANDING ADVANCE IN REMOTE METERING AND CONTROL

To the one-well plant or the giant municipal system, Sparton offers lower control costs, savings in supervisory time, plus flexibility for easy expansion or modification.

Each Sparton system is tailored to requirements through assembly of standard "building block" packages. Sparton techniques, time-proven through years of telegraphy and telephonic communication use, assure reliable, trouble-free service.

STANDARD PLUG-IN MODULES offer variety of control and supervisory techniques—discreet control and supervision with polarized d.c. pulses, time coded d.c. pulses or pulse-time coding; proportional control and supervision with polarized d.c. signals, d.c. pulses or continuous d.c. signals; channel multiplexing by flip-flop, multi-channel scanning or tones.



10-STATION WELL FIELD CONTROL with multi-channel scanning eliminates delays in re-starting remote pumps, minimizes capacity loss due to lightning-induced failures for Kansas system. Control center at treatment plant enables remote control and supervision of each well, plus restart programming. Typical of the many Sparton systems enabling better service at lower cost.

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DeCarlo, Victor E., Field Engr., Box 94, Paoli, Ind. (Oct. '56) *P*

DeLaxe, Ken, Southern Ind. Eng. Co., Inc., Medical Arts Bldg., Columbus, Ind. (Oct. '56) *MRPD*

Dorman, Gene, Supt., Water Dept., S. Oak St., Red Key, Ind. (Oct. '56) *MPD*

Drake, Charles W., Sr. Utilities Engr., Hydraulic Sec., State Public Utilities Com., 1000 Bldg., Los Angeles, Calif. (Oct. '56) *M*

Dreyer, Elsie (Miss), Pres., Town Board, Summan, Ind. (Oct '56) *MPD*

Dituri, Victor, Los Angeles County Engr., Water Works Div., 720 N. Spring St., Los Angeles 12, Calif. (Oct. '56) *MD*

Dixon, D., Director of Eng., Pantech, Inc., 5847 Centre Ave., Pittsburgh 6, Pa. (Oct. '56) *MD*

Dyer, Teddy R., Supt. of Production, Northern Illinois Water Corp., 122 N. Walnut St., Champaign, Ill. (Oct. '56) *RP*

Eaton, H. Arnold, Supt. of Utilities, Red Bluff, Calif. (Oct. '56) *MD*

Engle, Warren G.; *see* Combination Pump Valve Co.

Fajardo, Mario, San. & Civ. Engr., 17 Shepard St., Cambridge, Mass. (Oct. '56) *RPD*

Fielding, Hugh R., Control & Metering Ltd., 2271A Bloor St., W., Toronto 9, Ont. (Apr. '56)

Fisher, E. W.; *see* Garlock Packing Co.

Fogarty, Joseph T., Sales, J. B. Clow & Sons, 301 Sherland Bldg., South Bend, Ind. (Oct. '56) *MD*

Frye, Othmar G., Mayor, Washington, Ind. (Oct. '56) *M*

Fulford, Jim Henry, Supt., Water Dept., Dawson, Ga. (Oct. '56) *M*

Gardner, Robert C., Worthington Corp., South Bend, Ind. (Oct. '56) *MRPD*

Garlock Packing Co., E. W. Fisher, Mgr., Service Dept., 402 Main St., Palmyra, N.Y. (Assoc. M. Jul. '56)

Goodlander, Oliver S., Sales Repr., Ford Meter Box Co., Inc., Wabash, Ind. (Oct. '56) *MRD*

Grubaugh, Darrel, Supt. of Water, Oaktown, Ind. (Oct. '56) *MD*

Gunnarson, LeRoy; *see* Service Hardware & Equipment Co.

Gustafson, Robert P., Water Supt., Lake Crystal, Minn. (Oct. '56) *MD*

Hackney, William L., Jr., Sales Repr., James B. Clow & Sons, Chicago, Ill. (Oct. '56)

Hall, Wyatt E., Supervisor, Water & Sewer Dept., Port Arthur, Tex. (Oct. '56)

Harner, Robert Edgar, Mgr., Munic. Authority, 223 Baltimore St., Gettysburg, Pa. (Oct. '56) *M*

Harris, Walter S., Town Clerk, Akron, Ind. (Oct. '56) *MPD*

Heaney, James B., Water Supt., 608 Prospect Ave., Spring Lake Heights, N.J. (Oct. '56) *PD*

Hill, William H., Sales Repr., Mueller Co., Box 642, Walnut Creek, Calif. (Oct. '56)

Hixson, Norman G., Gen. Mgr., Cucamonga County Water Dist., 9314 San Bernardino Rd., Cucamonga, Calif. (Oct. '56) *MRPD*

Hoffman, James M., Jr., Sales Repr., Kennedy Valve Mfg. Co., Elmira, N.Y. (Oct. '56)

Holzmacher, Robert G., Engr., Henry G. Holzmacher & Assocs., 66 W. Marie St., Hicksville, N.Y. (Oct. '56) *RD*

Huwig, George C., Water Supt., Griffith, Ind. (Oct. '56) *MPD*

Jefferson, W. D., Mayor, Rochester, Ind. (Oct. '56) *M*

Jones, Lawrence Verne, Asst. Civ. Engr., Water Dept., Balboa Park, San Diego, Calif. (Oct. '56) *D*

Kessler, Alex Edward, Sales Engr., James B. Clow & Sons, Inc., Box 198, Ripon, Wis. (Oct. '56) *D*

Kinney, S. P.; *see* Kinney, S. P., Engrs., Inc.

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Kinney, S. P., Engineers, Inc., S. P. Kinney, Pres., 201—2nd Ave., Carnegie, Pa. (Assoc. M. Jul. '56)

Kuhn, Paul Anton, Engr., Stanley Eng. Co., Hershey Bldg., Muscatine, Iowa (Oct. '56) *MP*

Ladd, William K., Foreman, Florida Keys Aqueduct Com., Box 552, Key West, Fla. (Oct. '56) *D*

Linker, Kurt H., Salesman, Keasbey & Mattison Co., 1601 Haverty Bldg., Atlanta, Ga. (Oct. '56)

Lufkin, Eben P.; *see* Red Hed Mfg. Co.

M-C-G Company, Inc., Robert F. McGivern, Pres., 1771 W. 5th Ave., Columbus 12, Ohio (Assoc. M. Oct. '56)

MacCauley, Charles Morris, Jr., Civ. Eng. Asst., Dept. of Water & Power, Box 3669, Terminal Annex, Los Angeles 54, Calif. (Oct. '56) *M*

Macks, Morton Joseph, Vice-Pres. in Charge of Design & Constr., Admiral Constr. Co., 235 Equitable Bldg., Baltimore 2, Md. (Oct. '56) *D*

Mahoney, Chester Irven, Supt., Water Dept., Spiceland, Ind. (Oct. '56) *MPD*

Marks, Murray C., Chemist, Water Works, City Hall, Cedar Rapids, Iowa (Oct. '56) *P*

Masgrave, Edna (Mrs.), Secy.-Treas., Peoples Water Co., Inc., 2133 Cline Ave., Gary, Ind. (Oct. '56) *M*

Maurer, Frederick Carl, Asst. Editor, *Water & Sewage Works,* Scranton Publishing Co., 155 E. 44th St., New York 17, N.Y. (Oct. '56)

McBain, Kenneith C.; *see* Tork-Master Div. of Harvill Corp.

McClintock, Wilmer, Mayor, Monticello, Ind. (Oct. '56) *M*

McCoy, Ted, Mayor, Brazil, Ind. (Oct. '56) *MRD*

McCullough, Charles F., Supt., Light & Water Dept., Rockville, Ind. (Oct. '56) *MPD*

McDade, John J., Jr., Engr., California Water & Telephone Co., 300 Montgomery St., San Francisco, Calif. (Oct. '56) *M*

McDaniel, Robert Francis, Sales Repr., Miracle Chem. Solvent Corp., 1702 Winter St., Fort Wayne, Ind. (Oct. '56) *RD*

McGivern, Robert F.; *see* M-C-G Co.

McKinney, Glenn, Supt., Dept. of Water, Remington, Ind. (Oct. '56) *MD*

McLaughlin, Thad G., Dist. Geologist, Ground Water Branch, US Geological Survey, Federal Center, Denver, Colo. (Oct. '56) *R*

Merkel, Ralph, Supt. of Water, Kentland, Ind. (Oct. '56) *MPD*

Mitchell, W. R., Pipeline Contractor, Box 3175, Prichard, Ala. (Oct. '56) *D*

Montie, Leonard A., Asst. Supt., Water Dept., Appleton, Wis. (Oct. '56) *P*

Moore, Robert D., Mayor, 107 E. 2nd St., Bicknell, Ind. (Oct. '56) *MRPD*

Morgavan, John, Director, Peoples Water Co., Inc., 2133 Cline Ave., Gary, Ind. (Oct. '56) *M*

Mulford, Stewart F., Engr., Griscom-Russell Co., 225 Wetmore Ave., Massillon, Ohio (Oct. '56) *RP*

National Tank Maintenance Corp., Harry H. Covey, Pres., 1617 Crocker St., Des Moines, Iowa (Assoc. M. Oct. '56)

Red Hed Mfg. Co., Eben P. Lufkin, Pres., 368 Congress St., Boston, Mass. (Assoc. M. Jul. '56)

Service Hardware & Equipment Co., LeRoy Gunnarson, 151–155 Bay St., Tacoma, Wash. (Assoc. M. Jul. '56)

Southeastern Contracting Co., W. P. Cox Jr., Partner, Box 9068, Mountain Brook Sta., Birmingham 9, Ala. (Assoc. M. Jul. '56)

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Infilco Inc.
F. B. Leopold Co.
Omega Machine Co. (Div., B-I-F Industries)
Permutit Co.
Roberts Filter Mfg. Co.
Simplex Valve & Meter Co.
Stuart Corp.
Wallace & Tiernan Inc.

Fittings, Copper Pipe:
Dresser Mfg. Div.
M. Greenberg's Sons
Hays Mfg. Co.
Mueller Co.

Fittings, Tees, Ells, etc.:
Alco Products, Inc.
Cast Iron Pipe Research Assn.
James B. Clow & Sons
Crane Co.
Dresser Mfg. Div.
M & H Valve & Fittings Co.
Trinity Valley Iron & Steel Co.
United States Pipe & Foundry Co
R. D. Wood Co.

Flocculating Equipment:
Chain Belt Co.
Cochrane Corp.
Dorr-Oliver Inc.
General Filter Co.
Graver Water Conditioning Co.
Infilco Inc.
F. B. Leopold Co.
Permutit Co.
Stuart Corp.

Fluoride Chemicals:
American Agricultural Chemical Co.

Fluoride Feeders:
Fischer & Porter Co.
Omega Machine Co. (Div., B-I-F Industries)
Proportioneers, Inc. (Div., B-I-F Industries)
Wallace & Tiernan Co., Inc.

Furnaces:
Jos. G. Pollard Co., Inc.

Gages, Liquid Level:
Builders-Providence, Inc. (Div., B-I-F Industries)
Infilco Inc.
Minneapolis-Honeywell Regulator Co.
Simplex Valve & Meter Co.
Wallace & Tiernan Inc.

Gages, Loss of Head, Pressure & Vacuum, Rate of Flow, Sand Expansion:
Builders-Providence, Inc. (Div., B-I-F Industries)
Foxboro Co.
Infilco Inc.
Minneapolis-Honeywell Regulator Co.
Jos. G. Pollard Co., Inc.
Simplex Valve & Meter Co.
Wallace & Tiernan Inc.

Gasholders:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Hammond Iron Works
Pittsburgh-Des Moines Steel Co.

Gaskets, Rubber Packing:
James B. Clow & Sons
Johns-Manville Corp.

Gates, Shear and Sluice:
Armco Drainage & Metal Products, Inc.
Chapman Valve Mfg. Co.
James B. Clow & Sons
Morse Bros. Mchy. Co.
Mueller Co.
R. D. Wood Co.

Gears, Speed Reducing:
DeLaval Steam Turbine Co.
Philadelphia Gear Works, Inc.

Glass Standards—Colorimetric Analysis Equipment:
Klett Mfg. Co.
Wallace & Tiernan Inc.

Goosenecks (with or without Corporation Stops):
James B. Clow & Sons
Hays Mfg. Co.
Mueller Co.

Hydrants:
James B. Clow & Sons
Darling Valve & Mfg. Co.
M. Greenberg's Sons
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
A. P. Smith Mfg. Co.
Rensselaer Valve Co.
R. D. Wood Co.

Hydrogen Ion Equipment:
Wallace & Tiernan Inc.

Hypochlorite; see Calcium Hypochlorite; Sodium Hypochlorite

Ion Exchange Materials:
Allis-Chalmers Mfg. Co.
Cochrane Corp.
General Filter Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Roberts Filter Mfg. Co.

Iron, Pig:
Woodward Iron Co.

Iron Removal Plants:
American Well Works
Chain Belt Co.
Cochrane Corp.
General Filter Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.

Jointing Materials:
Hydraulic Development Corp.
Johns-Manville Corp.
Keasbey & Mattison Co.
Leadite Co., Inc.

Joints, Mechanical, Pipe:
American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
James B. Clow & Sons
Dresser Mfg. Div.
Trinity Valley Iron & Steel Co.
United States Pipe & Foundry Co.
R. D. Wood Co.

Leak Detectors:
Jos. G. Pollard Co., Inc.

Lime Slakers and Feeders:
Dorr-Oliver Inc.
General Filter Co.
Infilco Inc.
Omega Machine Co. (Div., B-I-F Industries)
Permutit Co.
Wallace & Tiernan Inc.

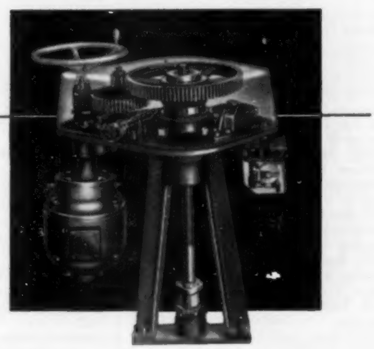
Magnetic Dipping Needles:
W. S. Darley & Co.

Meter Boxes:
Ford Meter Box Co.
Pittsburgh Equitable Meter Div.

2 TO 1
in Your favor

CHAPMAN
MOTOR UNITS

...for Valves, Floorstands, and Sluice Gates



It's a matter of simple mathematics. Take any one of Chapman's Motor Units and look it over carefully. You'll find approximately half as many parts as with any other make. This means the chances of cutting maintenance costs are two to one in your favor.

The odds can be even better. With Chapman Motor Units, you not only get simplified design, you also get sturdy construction and smooth, accurate performance over a longer period of time. There's no drift. Backlash is low. An accurate micrometer-controlled limit switch keeps seat tightness at any predetermined level.

Two points more — with Chapman Motor Units there's no trouble with either operating positions or operating conditions. Rugged stub-tooth gears require no grease or oil . . . operate at any angle . . . and the complete unit is not only weatherproof. It's *steam tight*.

Even on installation there's a chance of saving money with Chapman Motor Units. When used with floorstands they are completely wired at the factory . . . ready to connect and work. It's an easy, simple, low-cost job.

Chapman Motor Units for valves, floorstands, and sluice gates are outlined in full in our Catalog 51. If you don't have it, write for it, right now.

The CHAPMAN Valve Mfg. Company
INDIAN ORCHARD, MASSACHUSETTS

Meter Couplings and Yokes:
Badger Meter Mfg. Co.
Dresser Mfg. Div.
Ford Meter Box Co.
Hays Mfg. Co.
Hersey Mfg. Co.
Mueller Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
Worthington-Gamon Meter Co.

Meter Reading and Record Books:
Badger Meter Mfg. Co.

Meter Testers:
Badger Meter Mfg. Co.
Ford Meter Box Co.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.

Meters, Domestic:
Badger Meter Mfg. Co.
Buffalo Meter Co.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
Well Machinery & Supply Co.
Worthington-Gamon Meter Co.

Meters, Filtration Plant, Pumping Station, Transmission Line:
Builders-Providence, Inc. (Div., B-I-F Industries)
Foster Eng. Co.
Infilco Inc.
Minneapolis-Honeywell Regulator Co.
Simplex Valve & Meter Co.

Meters, Industrial, Commercial:
Badger Meter Mfg. Co.
Buffalo Meter Co.
Builders-Providence, Inc. (Div., B-I-F Industries)
Fischer & Porter Co.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
Simplex Valve & Meter Co.
Well Machinery & Supply Co.
Worthington-Gamon Meter Co.

Mixing Equipment:
Chain Belt Co.
General Filter Co.
Infilco Inc.
F. B. Leopold Co.

Paints:
Barrett Div.
Inertol Co., Inc.

Pipe, Asbestos-Cement:
Johns-Manville Corp.
Keasbey & Mattison Co.

Pipe, Brass:
American Brass Co.

Pipe, Cast Iron (and Fittings):
Alabama Pipe Co.
American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
James B. Clow & Sons
Trinity Valley Iron & Steel Co.
United States Pipe & Foundry Co.
R. D. Wood Co.

Pipe, Cement Lined:
American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
James B. Clow & Sons
United States Pipe & Foundry Co.
R. D. Wood Co.

Pipe, Concrete:
American Concrete Pressure Pipe Assn.
American Pipe & Construction Co.
Lock Joint Pipe Co.

Pipe, Copper:
American Brass Co.

Pipe, Steel:
Alco Products, Inc.
Armco Drainage & Metal Products, Inc.
Bethlehem Steel Co.

Pipe Cleaning Services:
Ace Pipe Cleaning, Inc.
National Water Main Cleaning Co.

Pipe Cleaning Tools and Equipment:
Flexible Inc.

Pipe Coatings and Linings:
Barrett Div.
Cast Iron Pipe Research Assn.
Centriline Corp.
Inertol Co., Inc.
Koppers Co., Inc.
Reilly Tar & Chemical Corp.

Pipe Cutters:
James B. Clow & Sons
Ellis & Ford Mfg. Co.
Jos. G. Pollard Co., Inc.
Reed Mfg. Co.
A. P. Smith Mfg. Co.
Spring Load Mfg. Corp.

Pipe Jointing Materials; see Jointing Materials

Pipe Locators:
W. S. Darley & Co.
Jos. G. Pollard Co., Inc.

Pipe Vises:
Reed Mfg. Co.
Spring Load Mfg. Corp.

Plugs, Removable:
James B. Clow & Sons
Jos. G. Pollard Co., Inc.
A. P. Smith Mfg. Co.

Potassium Permanganate:
Carus Chemical Co.

Pressure Regulators:
Allis-Chalmers Mfg. Co.
Foster Eng. Co.
Golden-Anderson Valve Specialty Co.
Mueller Co.
Ross Valve Mfg. Co.

Pumps, Boiler Feed:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.

Pumps, Centrifugal:
Allis-Chalmers Mfg. Co.
American Well Works
DeLaval Steam Turbine Co.
Morse Bros. Mchy. Co.
C. H. Wheeler Mfg. Co.

Pumps, Chemical Feed:
Infilco Inc.
Proportioneers, Inc. (Div., B-I-F Industries)
Wallace & Tiernan Inc.

Pumps, Deep Well:
American Well Works
Layne & Bowler, Inc.

Pumps, Diaphragm:
Dorr-Oliver Inc.
Morse Bros. Mchy. Co.
Wallace & Tiernan Inc.

Pumps, Hydrant:
W. S. Darley & Co.
Jos. G. Pollard Co., Inc.

Pumps, Hydraulic Booster:
Ross Valve Mfg. Co.

Pumps, Sewage:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.
C. H. Wheeler Mfg. Co.

Pumps, Sump:
DeLaval Steam Turbine Co.
C. H. Wheeler Mfg. Co.

Pumps, Turbine:
DeLaval Steam Turbine Co.
Layne & Bowler, Inc.

Recorders, Gas Density, CO_2, NH_3, SO_2, etc.:
Permutit Co.
Wallace & Tiernan Inc.

Recording Instruments:
Builders-Providence, Inc. (Div., B-I-F Industries)
Fischer & Porter Co.
Infilco Inc.
Minneapolis-Honeywell Regulator Co.
Simplex Valve & Meter Co.
Wallace & Tiernan Inc.

Reservoirs, Steel:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
R. D. Cole Mfg. Co.
Graver Water Conditioning Co.
Hammond Iron Works
Pittsburgh-Des Moines Steel Co.

Sand Expansion Gages; see Gages

Sleeves; see Clamps

Sleeves and Valves, Tapping:
James B. Clow & Sons
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.

Sludge Blanket Equipment:
General Filter Co.
Graver Water Conditioning Co.
Permutit Co.

Sodium Aluminate:
Monolith Portland Midwest Co.

Sodium Chloride:
Frontier Chemical Co.

Sodium Fluoride
American Agricultural Chemical Co.

Sodium Hexametaphosphate:
Calgon, Inc.

Sodium Hypochlorite:
John Wiley Jones Co.
Wallace & Tiernan Inc.

Sodium Silicate:
Philadelphia Quartz Co.

Sodium Silicofluoride
American Agricultural Chemical Co.

Softeners:
Cochrane Corp.
Dorr-Oliver Inc.
General Filter Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.

Softening Chemicals and Compounds:
Calgon, Inc.
Cochrane Corp.
General Filter Co.
Infilco Inc.
Morton Salt Co.
Permutit Co.
Tennessee Corp.

Standpipes, Steel:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
R. D. Cole Mfg. Co.
Graver Water Conditioning Co.
Hammond Iron Works
Pittsburgh-Des Moines Steel Co.

Steel Plate Construction:
Alco Products, Inc.
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
R. D. Cole Mfg. Co.
Graver Water Conditioning Co.
Hammond Iron Works
Pittsburgh-Des Moines Steel Co.

Stops, Curb and Corporation:
Hays Mfg. Co.
Mueller Co.

Storage Tanks; see Tanks

Strainers, Suction:
James B. Clow & Sons
M. Greenberg's Sons
Johnson, Edward E., Inc.
R. D. Wood Co.

Surface Wash Equipment:
Cochrane Corp.
Permutit Co.

Swimming Pool Sterilization:
Builders-Providence, Inc. (Div., B-I-F Industries)
Fischer & Porter Co.
Omega Machine Co. (Div., B-I-F Industries)
Proportioneers, Inc. (Div., B-I-F Industries)
Wallace & Tiernan Inc.

Tanks, Steel:
Alco Products, Inc.
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
R. D. Cole Mfg. Co.
Graver Water Conditioning Co.
Hammond Iron Works
Pittsburgh-Des Moines Steel Co.

Tapping-Drilling Machines:
Hays Mfg. Co.
Mueller Co.
A. P. Smith Mfg. Co.

Tapping Machines, Corp.:
Hays Mfg. Co.
Mueller Co.

Taste and Odor Removal:
Builders-Providence, Inc. (Div., B-I-F Industries)
Cochrane Corp.
General Filter Co.
Graver Water Conditioning Co.
Industrial Chemical Sales Div.
Infilco Inc.
Permutit Co.
Proportioneers, Inc. (Div., B-I-F Industries)
Wallace & Tiernan Inc.

Tenoning Tools:
Spring Load Mfg. Corp.

Turbidimetric Apparatus (For Turbidity and Sulfate Determinations):
Wallace & Tiernan Inc.

Turbines, Steam:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.

Turbines, Water:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.

Valve Boxes:
James B. Clow & Sons
Ford Meter Box Co.
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
Trinity Valley Iron & Steel Co.
R. D. Wood Co.

Valve-Inserting Machines:
Mueller Co.
A. P. Smith Mfg. Co.

Valves, Altitude:
Golden-Anderson Valve Specialty Co.
Ross Valve Mfg. Co., Inc.
S. Morgan Smith Co.

Valves, Butterfly, Check, Flap, Foot, Hose, Mud and Plug:
Builders-Providence, Inc. (Div., B-I-F Industries)
Chapman Valve Mfg. Co.
James B. Clow & Sons
DeZurik Shower Co.
M. Greenberg's Sons
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
Rensselaer Valve Co.
S. Morgan Smith Co.
R. D. Wood Co.

Valves, Detector Check:
Hersey Mfg. Co.

Valves, Electrically Operated:
Builders-Providence, Inc. (Div., B-I-F Industries)
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Philadelphia Gear Works, Inc.
Henry Pratt Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
S. Morgan Smith Co.

Valves, Float:
James B. Clow & Sons
Golden-Anderson Valve Specialty Co.
Henry Pratt Co.
Ross Valve Mfg. Co., Inc.

Valves, Gate:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Dresser Mfg. Div.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Hydraulically Operated:
Builders-Providence, Inc. (Div., B-I-F Industries)
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
DeZurik Shower Co.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
F. B. Leopold Co.
M & H Valve & Fittings Co.
Mueller Co.
Philadelphia Gear Works, Inc.
Henry Pratt Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
S. Morgan Smith Co.
R. D. Wood Co.

Valves, Large Diameter:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
S. Morgan Smith Co.
R. D. Wood Co.

Valves, Regulating:
DeZurik Shower Co.
Foster Eng. Co.
Golden-Anderson Valve Specialty Co.
Minneapolis-Honeywell Regulator Co.
Mueller Co.
Henry Pratt Co.
Ross Valve Mfg. Co.
S. Morgan Smith Co.

Valves, Swing Check:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
M. Greenberg's Sons
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Venturi Tubes:
Builders-Providence, Inc. (Div., B-I-F Industries)
Infilco Inc.
Simplex Valve & Meter Co.

Waterproofing:
Barrett Div.
Inertol Co., Inc.

Water Softening Plants; see Softeners

Water Supply Contractors:
Layne & Bowler, Inc.

Water Testing Apparatus:
Wallace & Tiernan Inc.

Water Treatment Plants:
American Well Works
Chain Belt Co.
Chicago Bridge & Iron Co.
Cochrane Corp.
Dorr-Oliver Inc.
Fischer & Porter Co.
General Filter Co.
Graver Water Conditioning Co.
Hammond Iron Works
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Pittsburgh-Des Moines Steel Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Wallace & Tiernan Inc.

Well Drilling Contractors:
Layne & Bowler, Inc.

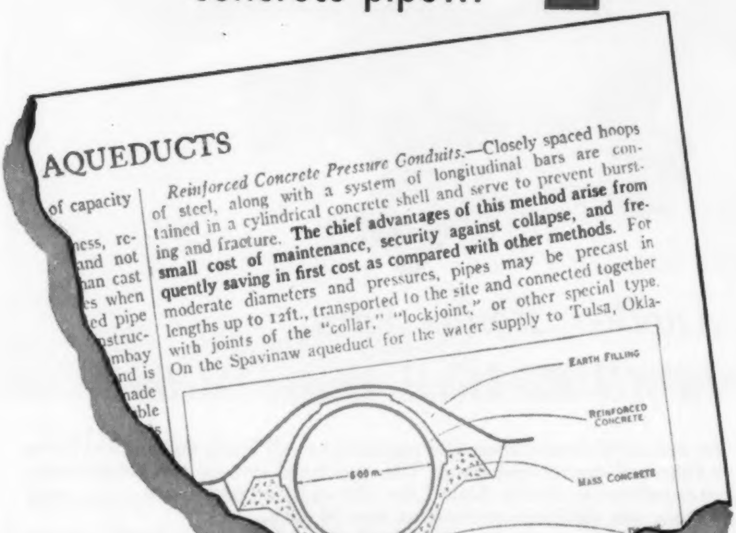
Well Screens:
Johnson, Edward E., Inc.

Wrenches, Ratchet:
Dresser Mfg. Div.

Zeolite; see Ion Exchange Materials

A complete Buyers' Guide to all water works products and services offered by AWWA Associate Members appears in the 1955 AWWA Directory.

Read what the Unbiased **Encyclopaedia Britannica** says about concrete pipe...



AQUEDUCTS

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Reinforced Concrete Pressure Conduits.—Closely spaced hoops of steel, along with a system of longitudinal bars are contained in a cylindrical concrete shell and serve to prevent bursting and fracture. **The chief advantages of this method arise from small cost of maintenance, security against collapse, and frequently saving in first cost as compared with other methods.** For moderate diameters and pressures, pipes may be precast in lengths up to 12ft., transported to the site and connected together with joints of the "collar," "lockjoint," or other special type. On the Spavinaw aqueduct for the water supply to Tulsa, Okla-

Concrete PRESSURE Pipe

WATER FOR GENERATIONS TO COME

Member companies are equipped to manufacture and furnish concrete pressure pipe in accordance with established national specifications and standards.

AMERICAN CONCRETE PRESSURE PIPE ASSOCIATION
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Chicago 1, Illinois